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(b) Twenty-four hour reports. Events to be reported to the NRC Operations Center within 24 hours of discovery, supplemented with the information in 10 CFR 70.50(c)(1) as it becomes available, followed by a written report within 30 days:

(1) Any event or condition that results in the facility being in a state that was not analyzed, was improperly analyzed, or is different from that analyzed in the Integrated Safety Analysis, and which results in failure to meet the performance requirements of § 70.61.

(2) Loss or degradation of items relied on for safety that results in failure to meet the performance requirement of § 70.61.

(3) An acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed materials that exceeds the quantitative standards that satisfy the requirements of § 70.61(c)(4).

(4) Any natural phenomenon or other external event, including fires internal and external to the facility, that has affected or may have affected the intended safety function or availability or reliability of one or more items relied on for safety.

(5) An occurrence of an event or process deviation that was considered in the Integrated Safety Analysis and:

(i) Was dismissed due to its likelihood; or
(ii) Was categorized as unlikely and whose associated unmitigated consequences would have exceeded those in § 70.61(b) had the item(s) relied on for safety not performed their safety function(s).

(c) Concurrent Reports. Any event or situation, related to the health and safety of the public or onsite personnel, or protection of the environment, for which a news release is planned or notification to other government agencies has been or will be made, shall be reported to the NRC Operations Center concurrent to the news release or other notification.

[65 FR 56231, Sept. 18, 2000]

PART 71—PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIAL

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APPENDIX A TO PART 71—DETERMINATION OF A₁ AND A₂

AUTHORITY: Secs. 53, 57, 62, 63, 81, 161, 182, 183, 68 Stat. 930, 932, 933, 935, 948, 953, 954, as amended, sec. 1701, 106 Stat. 2951, 2952, 2953 (42 U.S.C. 2073, 2077, 2092, 2093, 2111, 2201, 2232, 2233, 2297f); secs. 201, as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5846).

Section 71.97 also issued under sec. 301, Pub. L. 96-295, 94 Stat. 789-790.

SOURCE: 60 FR 50264, Sept. 28, 1995, unless otherwise noted.

Subpart A—General Provisions

§ 71.0 Purpose and scope.

(a) This part establishes—

(1) Requirements for packaging, preparation for shipment, and transportation of licensed material; and

(2) Procedures and standards for NRC approval of packaging and shipping procedures for fissile material and for a quantity of other licensed material in excess of a Type A quantity.

(b) The packaging and transport of licensed material are also subject to other parts of this chapter (e.g., 10 CFR parts 20, 21, 30, 40, 70, and 73) and to the regulations of other agencies (e.g., the U.S. Department of Transportation (DOT) and the U.S. Postal Service¹) having jurisdiction over means of transport. The requirements of this part are in addition to, and not in substitution for, other requirements.

(c) The regulations in this part apply to any licensee authorized by specific or general license issued by the Commission to receive, possess, use, or transfer licensed material, if the licensee delivers that material to a carrier for transport, transports the material outside the site of usage as specified in the NRC license, or transports that material on public highways. No provision of this part authorizes possession of licensed material.

(d) Exemptions from the requirement for license in § 71.3 are specified in § 71.10. General licenses for which no NRC package approval is required are issued in §§ 71.14 through 71.24. The general license in § 71.12 requires that an NRC certificate of compliance or other package approval be issued for the package to be used under the general license. Application for package approval must be completed in accordance with subpart D of this part, demonstrating that the design of the package to be used satisfies the package approval standards contained in subpart E of this part, as related to the tests of subpart F of this part. The transport of

¹Postal Service Manual (Domestic Mail Manual), section 124.3, which is incorporated by reference at 39 CFR 111.1.

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licensed material or delivery of licensed material to a carrier for transport is subject to the operating controls and procedures requirements of subpart G of this part, to the quality assurance requirements of subpart H of this part, and to the general provisions of subpart A of this part, including DOT regulations referenced in §71.5.

(e) The regulations in this part apply to any person required to obtain a certificate of compliance or an approved compliance plan pursuant to part 76 of this chapter if the person delivers radioactive material to a common or contract carrier for transport or transports the material outside the confines of the person's plant or other authorized place of use.

(f) This part also gives notice to all persons who knowingly provide to any licensee, certificate holder, quality assurance program approval holder, applicant for a license, certificate, or quality assurance program approval or to a contractor, or subcontractor of any of them, components, equipment, materials, or other goods or services, that relate to a licensee's, certificate holder's, quality assurance program approval holder's or applicant's activities subject to this part, that they may be individually subject to NRC enforcement action for violation of §71.11.

[60 FR 50264, Sept. 23, 1995, as amended at 63 FR 1899, Jan. 13, 1998]

§71.1 Communications and records.

(a) All communications concerning the regulations in this part should be addressed to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or may be delivered in person, at the Commission offices, at 11545 Rockville Pike, Rockville, Maryland.

(b) Each record required by this part must be legible throughout the retention period specified by each Commission regulation. The record may be the original or a reproduced copy or a microform provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of producing a clear copy throughout the required retention period. The record may also be stored in electronic media with the capability

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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. The licensee shall maintain adequate safeguards against tampering with and loss of records.

§71.2 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission, other than a written interpretation by the General Counsel, will be recognized to be binding upon the Commission.

§71.3 Requirement for license.

Except as authorized in a general license or a specific license issued by the Commission, or as exempted in this part, no licensee may—

- (a) Deliver licensed material to a carrier for transport; or
- (b) Transport licensed material.

§71.4 Definitions.

The following terms are as defined here for the purpose of this part. To ensure compatibility with international transportation standards, all limits in this part are given in terms of dual units: The International System of Units (SI) followed or preceded by U.S. standard or customary units. The U.S. customary units are not exact equivalents, but are rounded to a convenient value, providing a functionally equivalent unit. For the purpose of this part, either unit may be used.

A_1 means the maximum activity of special form radioactive material permitted in a Type A package. A_2 means the maximum activity of radioactive material, other than special form, LSA and SCO material, permitted in a Type A package. These values are either listed in Appendix A of this part, Table A-1, or may be derived in accordance with the procedure prescribed in Appendix A of this part.

Carrier means a person engaged in the transportation of passengers or property by land or water as a common, contract, or private carrier, or by civil aircraft.

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Certificate holder means a person who has been issued a certificate of compliance or other package approval by the Commission.

Close reflection by water means immediate contact by water of sufficient thickness for maximum reflection of neutrons.

Containment system means the assembly of components of the packaging intended to retain the radioactive material during transport.

Conveyance means:

(1) *For transport by public highway or rail* any transport vehicle or large freight container;

(2) *For transport by water* any vessel, or any hold, compartment, or defined deck area of a vessel including any transport vehicle on board the vessel; and

(3) *For transport by aircraft* any aircraft.

Exclusive use means the sole use by a single consignor of a conveyance for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee. The consignor and the carrier must ensure that any loading or unloading is performed by personnel having radiological training and resources appropriate for safe handling of the consignment. The consignor must issue specific instructions, in writing, for maintenance of exclusive use shipment controls, and include them with the shipping paper information provided to the carrier by the consignor.

Fissile material means plutonium-238, plutonium-239, plutonium-241, uranium-233, uranium-235, or any combination of these radionuclides. Unirradiated natural uranium and depleted uranium, and natural uranium or depleted uranium that has been irradiated in thermal reactors only are not included in this definition. Certain exclusions from fissile material controls are provided in § 71.53.

Licensed material means by-product, source, or special nuclear material received, possessed, used, or transferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter.

Low Specific Activity (LSA) material means radioactive material with lim-

ited specific activity that satisfies the descriptions and limits set forth below. Shielding materials surrounding the LSA material may not be considered in determining the estimated average specific activity of the package contents. LSA material must be in one of three groups:

(1) *LSA-I.* (i) Ores containing only naturally occurring radionuclides (e.g., uranium, thorium) and uranium or thorium concentrates of such ores; or

(ii) Solid unirradiated natural uranium or depleted uranium or natural thorium or their solid or liquid compounds or mixtures; or

(iii) Radioactive material, other than fissile material, for which the A_2 value is unlimited; or

(iv) Mill tailings, contaminated earth, concrete, rubble, other debris, and activated material in which the radioactive material is essentially uniformly distributed, and the average specific activity does not exceed 10^{-6} A_2/g .

(2) *LSA-II.* (i) Water with tritium concentration up to 0.8 TBq/liter (20.0 Ci/liter); or

(ii) Material in which the radioactive material is distributed throughout, and the average specific activity does not exceed 10^{-4} A_2/g for solids and gases, and 10^{-5} A_2/g for liquids.

(3) *LSA-III.* Solids (e.g., consolidated wastes, activated materials) in which:

(i) The radioactive material is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, ceramic, etc.); and

(ii) The radioactive material is relatively insoluble, or it is intrinsically contained in a relatively insoluble material, so that, even under loss of packaging, the loss of radioactive material per package by leaching, when placed in water for 7 days, would not exceed $0.1 A_2$; and

(iii) The average specific activity of the solid does not exceed 2×10^{-3} A_2/g .

Low toxicity alpha emitters means natural uranium, depleted uranium, natural thorium; uranium-235, uranium-238, thorium-232, thorium-228 or thorium-230 when contained in ores or physical or chemical concentrates or

tailings; or alpha emitters with a half-life of less than 10 days.

Maximum normal operating pressure means the maximum gauge pressure that would develop in the containment system in a period of 1 year under the heat condition specified in §71.71(c)(1), in the absence of venting, external cooling by an ancillary system, or operational controls during transport.

Natural thorium means thorium with the naturally occurring distribution of thorium isotopes (essentially 100 weight percent thorium-232).

Normal form radioactive material means radioactive material that has not been demonstrated to qualify as “special form radioactive material.”

Optimum interspersed hydrogenous moderation means the presence of hydrogenous material between packages to such an extent that the maximum nuclear reactivity results.

Package means the packaging together with its radioactive contents as presented for transport.

(1) *Fissile material package* means a fissile material packaging together with its fissile material contents.

(2) *Type B package* means a Type B packaging together with its radioactive contents. On approval, a Type B package design is designated by NRC as B(U) unless the package has a maximum normal operating pressure of more than 700 kPa (100 lb/in²) gauge or a pressure relief device that would allow the release of radioactive material to the environment under the tests specified in §71.73 (hypothetical accident conditions), in which case it will receive a designation B(M). B(U) refers to the need for unilateral approval of international shipments; B(M) refers to the need for multilateral approval of international shipments. There is no distinction made in how packages with these designations may be used in domestic transportation. To determine their distinction for international transportation, see DOT regulations in 49 CFR part 173. A Type B package approved before September 6, 1983, was designated only as Type B. Limitations on its use are specified in §71.13.

Packaging means the assembly of components necessary to ensure compliance with the packaging requirements of this part. It may consist of

one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle, tie-down system, and auxiliary equipment may be designated as part of the packaging.

Special form radioactive material means radioactive material that satisfies the following conditions:

(1) It is either a single solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule;

(2) The piece or capsule has at least one dimension not less than 5 mm (0.2 in); and

(3) It satisfies the requirements of §71.75. A special form encapsulation designed in accordance with the requirements of §71.4 in effect on June 30, 1983, (see 10 CFR part 71, revised as of January 1, 1983), and constructed before July 1, 1985, and a special form encapsulation designed in accordance with the requirements of §71.4 in effect on March 31, 1996, (see 10 CFR part 71, revised as of January 1, 1983), and constructed before April 1, 1998, may continue to be used. Any other special form encapsulation must meet the specifications of this definition.

Specific activity of a radionuclide means the radioactivity of the radionuclide per unit mass of that nuclide. The specific activity of a material in which the radionuclide is essentially uniformly distributed is the radioactivity per unit mass of the material.

State means a State of the United States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

Surface Contaminated Object (SCO) means a solid object that is not itself classed as radioactive material, but which has radioactive material distributed on any of its surfaces. SCO must be in one of two groups with surface activity not exceeding the following limits:

(1) SCO-I: A solid object on which:

(i) The non-fixed contamination on the accessible surface averaged over 300 cm² (or the area of the surface if less than 300 cm²) does not exceed 4 Bq/cm² (10⁻⁴ microcurie/cm²) for beta and

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gamma and low toxicity alpha emitters, or 0.4 Bq/cm^2 (10^{-5} microcurie/cm²) for all other alpha emitters;

(ii) The fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed $4 \times 10^4 \text{ Bq/cm}^2$ (1.0 microcurie/cm²) for beta and gamma and low toxicity alpha emitters, or $4 \times 10^3 \text{ Bq/cm}^2$ (0.1 microcurie/cm²) for all other alpha emitters; and

(iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed $4 \times 10^4 \text{ Bq/cm}^2$ (1 microcurie/cm²) for beta and gamma and low toxicity alpha emitters, or $4 \times 10^3 \text{ Bq/cm}^2$ (0.1 microcurie/cm²) for all other alpha emitters.

(2) SCO-II: A solid object on which the limits for SCO-I are exceeded and on which:

(i) The non-fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 400 Bq/cm^2 (10^{-2} microcurie/cm²) for beta and gamma and low toxicity alpha emitters or 40 Bq/cm^2 (10^{-3} microcurie/cm²) for all other alpha emitters;

(ii) The fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed $8 \times 10^5 \text{ Bq/cm}^2$ (20 microcuries/cm²) for beta and gamma and low toxicity alpha emitters, or $8 \times 10^4 \text{ Bq/cm}^2$ (2 microcuries/cm²) for all other alpha emitters; and

(iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed $8 \times 10^5 \text{ Bq/cm}^2$ (20 microcuries/cm²) for beta and gamma and low toxicity alpha emitters, or $8 \times 10^4 \text{ Bq/cm}^2$ (2 microcuries/cm²) for all other alpha emitters.

Transport index means the dimensionless number (rounded up to the next tenth) placed on the label of a package, to designate the degree of control to be exercised by the carrier

during transportation. The transport index is determined as follows:

(1) For non-fissile material packages, the number determined by multiplying the maximum radiation level in millisievert (mSv) per hour at one meter (3.3 ft) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at one meter (3.3 ft)); or

(2) For fissile material packages, the number determined by multiplying the maximum radiation level in millisievert per hour at one meter (3.3 ft) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at one meter (3.3 ft)), or, for criticality control purposes, the number obtained as described in § 71.59, whichever is larger.

Type A quantity means a quantity of radioactive material, the aggregate radioactivity of which does not exceed A_1 for special form radioactive material, or A_2 , for normal form radioactive material, where A_1 and A_2 are given in Table A-1 of this part, or may be determined by procedures described in Appendix A of this part.

Type B quantity means a quantity of radioactive material greater than a Type A quantity.

Uranium—natural, depleted, enriched

(1) *Natural uranium* means uranium with the naturally occurring distribution of uranium isotopes (approximately 0.711 weight percent uranium-235, and the remainder by weight essentially uranium-238).

(2) *Depleted uranium* means uranium containing less uranium-235 than the naturally occurring distribution of uranium isotopes.

(3) *Enriched uranium* means uranium containing more uranium-235 than the naturally occurring distribution of uranium isotopes.

[60 FR 50264, Sept. 28, 1995; 61 FR 28724, June 6, 1996]

§ 71.5 Transportation of licensed material.

(a) Each licensee who transports licensed material outside the site of usage, as specified in the NRC license, or where transport is on public highways, or who delivers licensed material to a carrier for transport, shall comply

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with the applicable requirements of the DOT regulations in 49 CFR parts 170 through 189 appropriate to the mode of transport.

(1) The licensee shall particularly note DOT regulations in the following areas:

(i) Packaging—49 CFR part 173: Subparts A and B and I.

(ii) Marking and labeling—49 CFR part 172: Subpart D, §§172.400 through 172.407, §§172.436 through 172.440, and subpart E.

(iii) Placarding—49 CFR part 172: Subpart F, especially §§172.500 through 172.519, 172.556, and appendices B and C.

(iv) Accident reporting—49 CFR part 171: §§171.15 and 171.16.

(v) Shipping papers and emergency information—49 CFR part 172: Subparts C and G.

(vi) Hazardous material employee training—49 CFR part 172: Subpart H.

(vii) Hazardous material shipper/cARRIER registration—49 CFR part 107: Subpart G.

(2) The licensee shall also note DOT regulations pertaining to the following modes of transportation:

(i) Rail—49 CFR part 174: Subparts A through D and K.

(ii) Air—49 CFR part 175.

(iii) Vessel—49 CFR part 176: Subparts A through F and M.

(iv) Public Highway—49 CFR part 177 and parts 390 through 397.

(b) If DOT regulations are not applicable to a shipment of licensed material, the licensee shall conform to the standards and requirements of the DOT specified in paragraph (a) of this section to the same extent as if the shipment or transportation were subject to DOT regulations. A request for modification, waiver, or exemption from those requirements, and any notification referred to in those requirements, must be filed with, or made to, the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

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§71.6 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information

collection requirements contained in this part to the Office of Management and Budget (OMB) for approval, as required by the Paperwork Reduction Act (44 U.S.C. 3501 et seq.). The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. OMB has approved the information collection requirements contained in this part, under control number 3150-0008.

(b) The approved information collection requirements contained in this part appear in §§71.5, 71.6a, 71.7, 71.12, 71.13, 71.31, 71.33, 71.35, 71.37, 71.38, 71.39, 71.47, 71.85, 71.87, 71.89, 71.91, 71.93, 71.95, 71.97, 71.101, 71.103, 71.105, 71.107, 71.109, 71.111, 71.113, 71.115, 71.117, 71.119, 71.121, 71.123, 71.125, 71.127, 71.129, 71.131, 71.133, 71.135, and 71.137.

[60 FR 50264, Sept. 28, 1995, as amended at 62 FR 52189, Oct. 6, 1997]

§71.7 Completeness and accuracy of information.

(a) Information provided to the Commission by an applicant for a license, or by a licensee, or information required by statute or by the Commission's regulations, orders, or license conditions to be maintained by the applicant or the licensee must be complete and accurate in all material respects.

(b) Each applicant or licensee shall notify the Commission of information identified by the applicant or licensee as having, for the regulated activity, a significant implication for public health and safety or common defense and security. An applicant or licensee violates this requirement only if the applicant or licensee fails to notify the Commission of information that the applicant or licensee has identified as having a significant implication for public health and safety or common defense and security. Notification must be provided to the Administrator of the appropriate Regional Office within two working days of identifying the information. This requirement is not applicable to information that is already required to be provided to the Commission by other reporting or updating requirements.

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§ 71.8 Specific exemptions.

On application of any interested person or on its own initiative, the Commission may grant any exemption from the requirements of the regulations in this part that it determines is authorized by law and will not endanger life or property nor the common defense and security.

§ 71.9 Exemption of physicians.

Any physician licensed by a State to dispense drugs in the practice of medicine is exempt from § 71.5 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 10 CFR part 35 or the equivalent Agreement State regulations.

§ 71.10 Exemption for low-level materials.

(a) A licensee is exempt from all requirements of this part with respect to shipment or carriage of a package containing radioactive material having a specific activity not greater than 70 Bq/g (0.002 μ Ci/g).

(b) A licensee is exempt from all requirements of this part, other than § 71.5 and § 71.88, with respect to shipment or carriage of the following packages, provided the packages contain no fissile material, or the fissile material exemption standards of § 71.53 are satisfied:

(1) A package containing no more than a Type A quantity of radioactive material;

(2) 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 m from the unshielded material or objects does not exceed 10 mSv/h (1 rem/h); or

(3) A package transported within locations within the United States which contains only americium or plutonium in special form with an aggregate radioactivity not to exceed 20 curies.

(c) A licensee is exempt from all requirements of this part, other than §§ 71.5 and 71.88, with respect to shipment or carriage of low-specific-activity (LSA) material in group LSA-I, or

surface contaminated objects (SCOs) in group SCO-I.

§ 71.11 Deliberate misconduct.

(a) This section applies to any—

(1) Licensee;

(2) Certificate holder;

(3) Quality assurance program approval holder;

(4) Applicant for a license, certificate, or quality assurance program approval;

(5) Contractor (including a supplier or consultant) or subcontractor, to any person identified in paragraphs (a)(1) through (a)(4) of this section; or

(6) Employee of any person identified in paragraphs (a)(1) through (a)(5) of this section.

(b) A person identified in paragraph (a) of this section who knowingly provides to any entity, listed in paragraphs (a)(1) through (a)(5) of this section any components, materials, or other goods or services that relate to a licensee's, certificate holder's, quality assurance program approval holder's or applicant's activities subject to this part may not:

(1) Engage in deliberate misconduct that causes or would have caused, if not detected, a licensee, certificate holder, quality assurance program approval holder, or any applicant to be in violation of any rule, regulation, or order; or any term, condition, or limitation of any license, certificate or approval issued by the Commission; or

(2) Deliberately submit to the NRC, a licensee, a certificate holder, quality assurance program approval holder, an applicant for a license, certificate or quality assurance program approval, or a licensee's, applicant's, certificate holder's or quality assurance program approval holder's contractor or subcontractor, information that the person submitting the information knows to be incomplete or inaccurate in some respect material to the NRC.

(c) A person who violates paragraph (b)(1) or (b)(2) of this section may be subject to enforcement action in accordance with the procedures in 10 CFR part 2, subpart B.

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(d) For the purposes of paragraph (b)(1) of this section, deliberate misconduct by a person means an intentional act or omission that the person knows:

(1) Would cause a licensee, certificate holder, quality assurance program approval holder or applicant for a license, certificate, or quality assurance program approval to be in violation of any rule, regulation, or order; or any term, condition, or limitation, of any license or certificate issued by the Commission; or

(2) Constitutes a violation of a requirement, procedure, instruction, contract, purchase order, or policy of a licensee, certificate holder, quality assurance program approval holder, applicant, or the contractor or subcontractor of any of them.

[63 FR 1899, Jan. 13, 1998]

Subpart C—General Licenses

§ 71.12 General license: NRC-approved package.

(a) A general license is hereby issued to any licensee of the Commission 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 NRC.

(b) This general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the provisions of subpart H of this part.

(c) 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 this part; and

(3) Submits in writing to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, before the licensee's first use of the package, the licensee's name

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and license number and the package identification number specified in the package approval.

(d) This general license applies only when the package approval authorizes use of the package under this general license.

(e) For a Type B or fissile material package, the design of which was approved by NRC before April 1, 1996, the general license is subject to the additional restrictions of § 71.13.

§ 71.13 Previously approved package.

(a) A Type B package previously approved by NRC but not designated as B(U) or B(M) in the identification number of the NRC Certificate of Compliance, may be used under the general license of § 71.12 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 § 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 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 NRC but without the designation “-85” in the identification number of the NRC Certificate of Compliance, may be used under the general license of § 71.12 with the following additional conditions:

(1) Fabrication of the package is satisfactorily completed by April 1, 1999 as demonstrated by application of its model number in accordance with § 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 DOT regulations at 49 CFR 173.403; and

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(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.

(c) NRC will approve modifications to the design and authorized contents of a Type B package, or a fissile material package, previously approved by NRC, provided—

(1) The modifications of a Type B package are not significant with respect to the design, operating characteristics, or safe performance of the containment system, when the package is subjected to the tests specified in §§71.71 and 71.73;

(2) The modifications of a fissile material package are not significant, with respect to the prevention of criticality, when the package is subjected to the tests specified in §§71.71 and 71.73; and

(3) The modifications to the package satisfy the requirements of this part.

(d) NRC will revise the package identification number to designate previously approved package designs as B(U), B(M), AF, BF, or A as appropriate, and with the identification number suffix “-85” after receipt of an application demonstrating that the design meets the requirements of this part.

§71.14 General license: DOT specification container.

(a) A general license is issued to any licensee of the Commission to transport, or to deliver to a carrier for transport, licensed material in a specification container for fissile material or for a Type B quantity of radioactive material as specified in DOT regulations at 49 CFR parts 173 and 178.

(b) This general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the provisions of subpart H of this part.

(c) This general license applies only to a licensee who—

(1) Has a copy of the specification; and

(2) Complies with the terms and conditions of the specification and the applicable requirements of subparts A, G, and H of this part.

(d) This general license is subject to the limitation that the specification container may not be used for a shipment to a location outside the United States, except by multilateral approval, as defined in DOT regulations at 49 CFR 173.403.

§71.16 General license: Use of foreign approved package.

(a) A general license is issued to any licensee of the Commission 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 DOT as meeting the applicable requirements of 49 CFR 171.12.

(b) Except as otherwise provided in this section, the general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the applicable provisions of subpart H of this part.

(c) This general license applies only to shipments made to or from locations outside the United States.

(d) 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; and

(2) Complies with the terms and conditions of the certificate and revalidation, and with the applicable requirements of subparts A, G, and H of this part. With respect to the quality assurance provisions of subpart H of this part, the licensee is exempt from design, construction, and fabrication considerations.

§71.18 General license: Fissile material, limited quantity per package.

(a) A general license is issued to any licensee of the Commission to transport fissile material, or to deliver fissile material to a carrier for transport, without complying with the package standards of subparts E and F of this part, if the material is shipped in accordance with this section.

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(b) The general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the provisions of subpart H of this part.

(c) Except as provided in paragraph (d) of this section, this general license applies only when a package contains no more than a Type A quantity of radioactive material, including only one of the following:

- (1) Up to 40 g of uranium-235;
- (2) Up to 30 g of uranium-233;

(3) Up to 25 g of the fissile radionuclides of plutonium, except that for encapsulated plutonium-beryllium neutron sources in special form, an A₁ quantity of plutonium may be present; or

(4) A combination of fissile radionuclides in which the sum of the ratios of the amount of each radionuclide to the corresponding maximum amounts in paragraphs (c) (1), (2), and (3) of this section does not exceed unity.

(d) For packages where fissile material is mixed with substances having an average hydrogen density greater than water, this general license applies only when a package contains no more than a Type A quantity of radioactive material, including only one of the following:

- (1) Up to 29 g of uranium-235;
- (2) Up to 18 g of uranium-233;
- (3) Up to 18 g of fissile radionuclides of plutonium, or

(4) A combination of fissile radionuclides in which the sum of the ratios of the amount of each radionuclide to the corresponding maximum amounts in paragraphs (d) (1), (2), and (3) of this section does not exceed unity.

(e) Except for the beryllium contained within the special form plutonium-beryllium sources authorized in paragraph (c) of this section, this general license applies only when beryllium, graphite, or hydrogenous material enriched in deuterium is not present in quantities exceeding 0.1% of the fissile material mass.

(f)(1) Except as specified in paragraph (f)(2) of this section for encapsulated plutonium-beryllium sources, this general license applies only when, a package is labeled with a transport index not less than the number given by the following equation, where the package

contains x grams of uranium-235, y grams of uranium-233, and z grams of the fissile radionuclides of plutonium:

$$\text{Minimum Transport Index} = (0.25x + 0.33y + 0.4z).$$

(2) For a package in which the only fissile material is in the form of encapsulated plutonium-beryllium neutron sources in special form, the transport index based on criticality considerations may be taken as 0.025 times the number of grams of the fissile radionuclides of plutonium.

(3) Packages which have a transport index greater than 10 are not authorized under the general license provisions of this part.

[62 FR 5911, Feb. 10, 1997]

§ 71.20 General license: Fissile material, limited moderator per package.

(a) A general license is issued to any licensee of the Commission to transport fissile material, or to deliver fissile material to a carrier for transport, without complying with the package standards of subparts E and F of this part if the material is shipped in accordance with this section.

(b) The general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the provisions of subpart H of this part.

(c) This general license applies only when—

(1) The package contains no more than a Type A quantity of radioactive material;

(2) Neither beryllium nor hydrogenous material enriched in deuterium is present;

(3) The total mass of graphite present does not exceed 7.7 times the total mass of uranium-235 plus plutonium;

(4) Substances having a higher hydrogen density than water (e.g., certain hydrocarbon oils), are not present, except that polyethylene may be used for packing or wrapping;

(5) Uranium-233 is not present, and the amount of plutonium does not exceed 1 percent of the amount of uranium-235;

(6) The amount of uranium-235 is limited as follows:

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(i) If the fissile radionuclides are not uniformly distributed, the maximum amount of uranium-235 per package may not exceed the value given in Table I of this part; or

(ii) If the fissile radionuclides are distributed uniformly (i.e., cannot form a lattice arrangement within the packaging), the maximum amount of uranium-235 per package may not exceed the value given in Table II of this part; and

(7) The transport index of each package, based on criticality considerations, is taken as 10 times the number of grams of uranium-235 in the package divided by the maximum allowable number of grams per package in accordance with Table I or Table II of this part, as applicable.

TABLE II—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE MATERIAL PACKAGE, APPLICABLE TO § 71.20(C)(6)(II)

[Uniform Distribution]

Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per package
4	84
3.5	92
3	112
2.5	148
2	240
1.5	560
1.35	800

TABLE I—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE MATERIAL PACKAGE, APPLICABLE TO § 71.20(C)(6)(I)

[Nonuniform distribution]

Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per package
24	40
20	42
15	45
11	48
10	51
9.5	52
9	54
8.5	55
8	57
7.5	59
7	60
6.5	62
6	65
5.5	68
5	72
4.5	76
4	80
3.5	88
3	100
2.5	120
2	164
1.5	272
1.35	320
1	680
0.92	1,200

§ 71.22 General license: Fissile material, limited quantity, controlled shipment.

(a) A general license is issued to any licensee of the Commission to transport fissile material, or to deliver fissile material to a carrier for transport, without complying with the package standards of Subparts E and F of this part, if limited material is shipped in accordance with this section.

(b) The general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the provisions of Subpart H of this part.

(c) This general license applies only when a package contains no more than a Type A quantity of radioactive material and no more than 400 g total of the fissile radionuclides of plutonium encapsulated as plutonium-beryllium neutron sources in special form.

(d) This general license applies only when:

(1) The mass of fissile radionuclides in the shipment is limited such that the

$$\frac{\text{grams of uranium - 235}}{X} + \frac{\text{grams of other fissile material}}{Y} \leq 1$$

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where X and Y are the mass defined in the table following paragraph (d)(2) of this section; or

(2) the encapsulated plutonium-beryllium neutron sources are in special

form and the total mass of fissile radionuclides in the shipment does not exceed 2500 g.

PERMISSIBLE MASS LIMITS FOR SHIPMENTS OF FISSILE MATERIAL

Fissile material	Fissile material mass (g) mixed with substances having a hydrogen density less than or equal to water	Fissile material mass (g) mixed with substances having a hydrogen density greater than water
Uranium-235(X)	500	290
Other fissile material(Y)	300	180

(e) Except for the beryllium contained within the special form plutonium-beryllium sources authorized in paragraphs (c) and (d) of this section, this general license applies only when beryllium, graphite or hydrogenous material enriched in deuterium is not present in quantities exceeding 0.1% of the fissile material mass.

(f) This general license applies only when shipment of these packages is made under procedures specifically authorized by DOT, in accordance with 49 CFR Part 173 of its regulations, to prevent loading, transport, or storage of these packages with other fissile material shipments.

[62 FR 5912, Feb. 10, 1997]

§ 71.24 General license: Fissile material, limited moderator, controlled shipment.

(a) A general license is issued to any licensee of the Commission to transport fissile material, or to deliver fissile material to a carrier for transport, without complying with the package standards of subparts E and F of this part, if limited material is shipped in accordance with this section.

(b) The general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the provisions of subpart H of this part.

(c) This general license applies only when—

(1) No package contains more than a Type A quantity of radioactive material;

(2) The packaging does not incorporate lead shielding exceeding 5 cm in thickness, tungsten shielding, or uranium shielding;

(3) Neither beryllium nor hydrogenous material enriched in deuterium is present;

(4) The total mass of graphite present does not exceed 7.7 times the total mass of uranium-235 and plutonium;

(5) Substances having a higher hydrogen density than water (e.g., certain hydrocarbon oils), are not present, except that polyethylene may be used for packing or wrapping;

(6) For fissile contents containing no uranium-233 and less than 1 percent by weight total plutonium, if the fissile radionuclides are—

(i) Not uniformly distributed, the maximum amount of uranium-235 per consignment does not exceed the value given in Table III of this part; or

(ii) Distributed uniformly and cannot form a lattice arrangement within the packaging, the maximum amount of uranium-235 per shipment does not exceed the value given in Table IV of this part;

(7) For fissile contents containing uranium-233 or more than 1 percent by weight plutonium, the total mass of fissile material per shipment is limited so that the sum of the number of grams of uranium-235 divided by 400, the number of grams of plutonium divided by 225, and the number of grams of uranium-233 divided by 250, does not exceed unity, as expressed in the formula:

$$\frac{\text{grams uranium} - 235}{400 \text{ g}} + \frac{\text{grams plutonium}}{225 \text{ g}} + \frac{\text{grams uranium} - 233}{250 \text{ g}} \leq 1;$$

(8) The transport must be direct to the consignee without any intermediate transit storage; and

(9) Shipment of these packages is made under procedures specifically authorized by DOT in accordance with 49 CFR part 173 of its regulations to prevent loading, transport, or storage of these packages with other fissile material shipments.

TABLE III—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE MATERIAL SHIPMENT APPLICABLE TO § 71.24(C)(6)(I)
[Nonuniform distribution]

Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per consignment
20	520
15	560
11	600
10	640
9.5	655
9	675
8.5	690
8	710
7.5	730
7	750
6.5	780
6	810
5.5	850
5	900
4.5	950
4	1,000
3.5	1,100
3	1,250
2.5	1,500
2	2,050
1.5	3,400
1.35	4,000
1	8,500
0.92	15,000

TABLE IV—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE MATERIAL SHIPMENT APPLICABLE TO § 71.24(C)(6)(II)—Continued
[Uniform distribution]

Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per consignment
1.35	10,000

Subpart D—Application for Package Approval

§ 71.31 Contents of application.

(a) An application for an approval under this part must include, for each proposed packaging design, the following information:

(1) A package description as required by § 71.33;

(2) A package evaluation as required by § 71.35; and

(3) A quality assurance program description, as required by § 71.37, or a reference to a previously approved quality assurance program.

(b) Except as provided in § 71.13, an application for modification of a package design, whether for modification of the packaging or authorized contents, must include sufficient information to demonstrate that the proposed design satisfies the package standards in effect at the time the application is filed.

(c) The applicant shall identify any established codes and standards proposed for use in package design, fabrication, assembly, testing, maintenance, and use. In the absence of any codes and standards, the applicant shall describe and justify the basis and rationale used to formulate the package quality assurance program.

§ 71.33 Package description.

The application must include a description of the proposed package in sufficient detail to identify the package accurately and provide a sufficient basis for evaluation of the package. The description must include—

TABLE IV—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE MATERIAL SHIPMENT APPLICABLE TO § 71.24(C)(6)(II)
[Uniform distribution]

Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per consignment
4	1,050
3.5	1,150
3	1,400
2.5	1,800
2	3,000
1.5	7,000

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- (a) With respect to the packaging—
 - (1) Classification as Type B(U), Type B(M), or fissile material packaging;
 - (2) Gross weight;
 - (3) Model number;
 - (4) Identification of the containment system;
 - (5) Specific materials of construction, weights, dimensions, and fabrication methods of—
 - (i) Receptacles;
 - (ii) Materials specifically used as nonfissile neutron absorbers or moderators;
 - (iii) Internal and external structures supporting or protecting receptacles;
 - (iv) Valves, sampling ports, lifting devices, and tie-down devices; and
 - (v) Structural and mechanical means for the transfer and dissipation of heat; and
 - (6) Identification and volumes of any receptacles containing coolant.
- (b) With respect to the contents of the package—
 - (1) Identification and maximum radioactivity of radioactive constituents;
 - (2) Identification and maximum quantities of fissile constituents;
 - (3) Chemical and physical form;
 - (4) Extent of reflection, the amount and identity of nonfissile materials used as neutron absorbers or moderators, and the atomic ratio of moderator to fissile constituents;
 - (5) Maximum normal operating pressure;
 - (6) Maximum weight;
 - (7) Maximum amount of decay heat; and
 - (8) Identification and volumes of any coolants.

§ 71.35 Package evaluation.

The application must include the following:

- (a) A demonstration that the package satisfies the standards specified in subparts E and F of this part;
- (b) For a fissile material package, the allowable number of packages that may be transported in the same vehicle in accordance with § 71.59; and
- (c) For a fissile material shipment, any proposed special controls and precautions for transport, loading, unloading, and handling and any proposed special controls in case of an accident or delay.

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§ 71.37 Quality assurance.

- (a) The applicant shall describe the quality assurance program (see Subpart H of this part) for the design, fabrication, assembly, testing, maintenance, repair, modification, and use of the proposed package.
- (b) The applicant shall identify any specific provisions of the quality assurance program that are applicable to the particular package design under consideration, including a description of the leak testing procedures.

§ 71.38 Renewal of a certificate of compliance or quality assurance program approval.

- (a) Except as provided in paragraph (b) of this section, each Certificate of Compliance or Quality Assurance Program Approval expires at the end of the day, in the month and year stated in the approval.
- (b) In any case in which a person, not less than 30 days before the expiration of an existing Certificate of Compliance or Quality Assurance Program Approval issued pursuant to the part, has filed an application in proper form for renewal of either of those approvals, the existing Certificate of Compliance or Quality Assurance Program Approval for which the renewal application was filed shall not be deemed to have expired until final action on the application for renewal has been taken by the Commission.
- (c) In applying for renewal of an existing Certificate of Compliance or Quality Assurance Program Approval, an applicant may be required to submit a consolidated application that incorporates all changes to its program that, are incorporated by reference in the existing approval or certificate, into as few referenceable documents as reasonably achievable.

§ 71.39 Requirement for additional information.

The Commission may at any time require additional information in order to enable it to determine whether a license, certificate of compliance, or other approval should be granted, renewed, denied, modified, suspended, or revoked.

Subpart E—Package Approval Standards

§ 71.41 Demonstration of compliance.

(a) The effects on a package of the tests specified in § 71.71 (“Normal conditions of transport”), and the tests specified in § 71.73 (“Hypothetical accident conditions”), and § 71.61 (Special requirement for irradiated nuclear fuel shipments’), must be evaluated by subjecting a specimen or scale model to a specific test, or by another method of demonstration acceptable to the Commission, as appropriate for the particular feature being considered.

(b) Taking into account the type of vehicle, the method of securing or attaching the package, and the controls to be exercised by the shipper, the Commission may permit the shipment to be evaluated together with the transporting vehicle.

(c) Environmental and test conditions different from those specified in §§ 71.71 and 71.73 may be approved by the Commission if the controls proposed to be exercised by the shipper are demonstrated to be adequate to provide equivalent safety of the shipment.

§ 71.43 General standards for all packages.

(a) The smallest overall dimension of a package may not be less than 10 cm (4 in).

(b) The outside of a package must incorporate a feature, such as a seal, that is not readily breakable and that, while intact, would be evidence that the package has not been opened by unauthorized persons.

(c) Each package must include a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by a pressure that may arise within the package.

(d) A package must be made of materials and construction that assure that there will be no significant chemical, galvanic, or other reaction among the packaging components, among package contents, or between the packaging components and the package contents, including possible reaction resulting from inleakage of water, to the maximum credible extent. Account must be

taken of the behavior of materials under irradiation.

(e) A package valve or other device, the failure of which would allow radioactive contents to escape, must be protected against unauthorized operation and, except for a pressure relief device, must be provided with an enclosure to retain any leakage.

(f) A package must be designed, constructed, and prepared for shipment so that under the tests specified in § 71.71 (“Normal conditions of transport”) there would be no loss or dispersal of radioactive contents, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the packaging.

(g) A package must be designed, constructed, and prepared for transport so that in still air at 38°C (100°F) and in the shade, no accessible surface of a package would have a temperature exceeding 50°C (122°F) in a nonexclusive use shipment, or 85°C (185°F) in an exclusive use shipment.

(h) A package may not incorporate a feature intended to allow continuous venting during transport.

§ 71.45 Lifting and tie-down standards for all packages.

(a) Any lifting attachment that is a structural part of a package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting device under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package that could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport, or must be designed with strength equivalent to that required for lifting attachments.

(b) Tie-down devices:

(1) If there is a system of tie-down devices that is a structural part of the package, the system must be capable of withstanding, without generating stress in any material of the package in excess of its yield strength, a static force applied to the center of gravity of

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the package having a vertical component of 2 times the weight of the package with its contents, a horizontal component along the direction in which the vehicle travels of 10 times the weight of the package with its contents, and a horizontal component in the transverse direction of 5 times the weight of the package with its contents.

(2) Any other structural part of the package that could be used to tie down the package must be capable of being rendered inoperable for tying down the package during transport, or must be designed with strength equivalent to that required for tie-down devices.

(3) Each tie-down device that is a structural part of a package must be designed so that failure of the device under excessive load would not impair the ability of the package to meet other requirements of this part.

§71.47 External radiation standards for all packages.

(a) Except as provided in paragraph (b) of this section, each package of radioactive materials offered for transportation must be designed and prepared for shipment so that under conditions normally incident to transportation the radiation level does not exceed 2 mSv/h (200 mrem/h) at any point on the external surface of the package, and the transport index does not exceed 10.

(b) A package that exceeds the radiation level limits specified in paragraph (a) of this section must be transported by exclusive use shipment only, and the radiation levels for such shipment must not exceed the following during transportation:

(1) 2 mSv/h (200 mrem/h) on the external surface of the package, unless the following conditions are met, in which case the limit is 10 mSv/h (1000 mrem/h):

(i) The shipment is made in a closed transport vehicle;

(ii) The package is secured within the vehicle so that its position remains fixed during transportation; and

(iii) There are no loading or unloading operations between the beginning and end of the transportation;

(2) 2 mSv/h (200 mrem/h) at any point on the outer surface of the vehicle, in-

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cluding the top and underside of the vehicle; or in the case of a flat-bed style vehicle, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load or enclosure, if used, and on the lower external surface of the vehicle; and

(3) 0.1 mSv/h (10 mrem/h) at any point 2 meters (80 in) from the outer lateral surfaces of the vehicle (excluding the top and underside of the vehicle); or in the case of a flat-bed style vehicle, at any point 2 meters (6.6 feet) from the vertical planes projected by the outer edges of the vehicle (excluding the top and underside of the vehicle); and

(4) 0.02 mSv/h (2 mrem/h) in any normally occupied space, except that this provision does not apply to private carriers, if exposed personnel under their control wear radiation dosimetry devices in conformance with 10 CFR 20.1502.

(c) For shipments made under the provisions of paragraph (b) of this section, the shipper shall provide specific written instructions to the carrier for maintenance of the exclusive use shipment controls. The instructions must be included with the shipping paper information.

(d) The written instructions required for exclusive use shipments must be sufficient so that, when followed, they will cause the carrier to avoid actions that will unnecessarily delay delivery or unnecessarily result in increased radiation levels or radiation exposures to transport workers or members of the general public.

§71.51 Additional requirements for Type B packages.

(a) Except as provided in §71.52, a Type B package, in addition to satisfying the requirements of §§71.41 through 71.47, must be designed, constructed, and prepared for shipment so that under the tests specified in:

(1) Section 71.71 ("Normal conditions of transport"), there would be no loss or dispersal of radioactive contents—as demonstrated to a sensitivity of 10^{-6} A₂ per hour, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the packaging; and

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(2) Section 71.73 (“Hypothetical accident conditions”), there would be no escape of krypton-85 exceeding 10 A₂ in 1 week, no escape of other radioactive material exceeding a total amount A₂ in 1 week, and no external radiation dose rate exceeding 10 mSv/h (1 rem/h) at 1 m (40 in) from the external surface of the package.

(b) Where mixtures of different radionuclides are present, the provisions of appendix A, paragraph IV of this part shall apply, except that for Krypton-85, an effective A₂ value equal to 10 A₂ may be used.

(c) Compliance with the permitted activity release limits of paragraph (a) of this section may not depend on fil-

ters or on a mechanical cooling system.

§ 71.53 Fissile material exemptions.

Fissile materials meeting the requirements of one of the paragraphs in (a) through (d) of this section are exempt from fissile material classification and from the fissile material package standards of §§ 71.55 and 71.59, but are subject to all other requirements of this part. These exemptions apply only when beryllium, graphite, or hydrogenous material enriched in deuterium is not present in quantities exceeding 0.1 percent of the fissile material mass.

(a) Fissile material such that

$$\frac{\text{grams of uranium - 235}}{X} + \frac{\text{grams of other fissile material}}{Y} \leq 1$$

for an individual consignment, where X and Y are the mass limits defined in table following paragraph (a)(3) of this section, provided that:

(1) Each package contains no more than 15 g of fissile material. For unpackaged material the mass limit of 15g applies to the conveyance; or

(2) The fissile material consists of a homogeneous hydrogenous solution or mixture where the minimum ratio of

hydrogen atoms to fissile radionuclide atoms (H/X) is 5200 and the maximum concentration of fissile radionuclides within a package is 5 g/liter; or

(3) There is no more than 5g of fissile material in any 10 liter volume of material and the material is packaged so as to maintain this limit of fissile radionuclide concentration during normal transport.

THE REQUIREMENTS FOR PACKAGES CONTAINING FISSILE MATERIAL

Fissile material	Fissile material mass (g) mixed with substances having an average hydrogen density less than or equal to water	Fissile material mass (g) mixed with substances having an average hydrogen density greater than water
Uranium-235(X)	400	290
Other fissile material(Y)	250	180

(b) 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 fissile material is distributed homogeneously throughout the package contents and does not form a lattice arrangement within the package.

(c) Liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of 2 percent by weight, with a total plutonium and uranium-233 content not exceeding 0.1 percent of the mass of uranium-235, and with a minimum nitrogen to uranium atomic ratio (N/U) of 2.

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(d) Plutonium, less than 1 kg, of which not more than 20 percent by mass may consist of plutonium-239, plutonium-241, or any combination of these radionuclides.

[62 FR 5913, Feb. 10, 1997]

§ 71.55 General requirements for fissile material packages.

(a) A package used for the shipment of fissile material must be designed and constructed in accordance with §§ 71.41 through 71.47. When required by the total amount of radioactive material, a package used for the shipment of fissile material must also be designed and constructed in accordance with § 71.51.

(b) Except as provided in paragraph (c) of this section, a package used for the shipment of fissile material must be so designed and constructed and its contents so limited that it would be subcritical if water were to leak into the containment system, or liquid contents were to leak out of the containment system so that, under the following conditions, maximum reactivity of the fissile material would be attained:

(1) The most reactive credible configuration consistent with the chemical and physical form of the material;

(2) Moderation by water to the most reactive credible extent; and

(3) Close full reflection of the containment system by water on all sides, or such greater reflection of the containment system as may additionally be provided by the surrounding material of the packaging.

(c) The Commission may approve exceptions to the requirements of paragraph (b) of this section if the package incorporates special design features that ensure that no single packaging error would permit leakage, and if appropriate measures are taken before each shipment to ensure that the containment system does not leak.

(d) A package used for the shipment of fissile material must be so designed and constructed and its contents so limited that under the tests specified in § 71.71 (“Normal conditions of transport”)—

(1) The contents would be subcritical;

(2) The geometric form of the package contents would not be substantially altered;

(3) There would be no leakage of water into the containment system unless, in the evaluation of undamaged packages under § 71.59(a)(1), it has been assumed that moderation is present to such an extent as to cause maximum reactivity consistent with the chemical and physical form of the material; and

(4) There will be no substantial reduction in the effectiveness of the packaging, including:

(i) No more than 5 percent reduction in the total effective volume of the packaging on which nuclear safety is assessed;

(ii) No more than 5 percent reduction in the effective spacing between the fissile contents and the outer surface of the packaging; and

(iii) No occurrence of an aperture in the outer surface of the packaging large enough to permit the entry of a 10 cm (4 in) cube.

(e) A package used for the shipment of fissile material must be so designed and constructed and its contents so limited that under the tests specified in § 71.73 (“Hypothetical accident conditions”), the package would be subcritical. For this determination, it must be assumed that:

(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents;

(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents; and

(3) There is full reflection by water on all sides, as close as is consistent with the damaged condition of the package.

[60 FR 50264, Sept. 28, 1995; 61 FR 28724, June 6, 1996]

§ 71.57 [Reserved]

§ 71.59 Standards for arrays of fissile material packages.

(a) A fissile material package must be controlled by either the shipper or the carrier during transport to assure

that an array of such packages remains subcritical. To enable this control, the designer of a fissile material package shall derive a number "N" based on all the following conditions being satisfied, assuming packages are stacked together in any arrangement and with close full reflection on all sides of the stack by water:

(1) Five times "N" undamaged packages with nothing between the packages would be subcritical;

(2) Two times "N" damaged packages, if each package were subjected to the tests specified in § 71.73 ("Hypothetical accident conditions") would be subcritical with optimum interspersed hydrogenous moderation; and

(3) The value of "N" cannot be less than 0.5.

(b) The transport index based on nuclear criticality control must be obtained by dividing the number 50 by the value of "N" derived using the procedures specified in paragraph (a) of this section. The value of the transport index for nuclear criticality control may be zero provided that an unlimited number of packages is subcritical such that the value of "N" is effectively equal to infinity under the procedures specified in paragraph (a) of this section. Any transport index greater than zero must be rounded up to the first decimal place.

(c) Where a fissile material package is assigned a nuclear criticality control transport index—

(1) Not in excess of 10, that package may be shipped by any carrier, and that carrier provides adequate criticality control by limiting the sum of the transport indexes to 50 in a non-exclusive use vehicle, and to 100 in an exclusive use vehicle.

(2) In excess of 10, that package may only be shipped by exclusive use vehicle or other shipper controlled system specified by DOT for fissile material packages. The shipper provides adequate criticality control by limiting the sum of the transport indexes to 100 in an exclusive use vehicle.

§ 71.61 Special requirement for irradiated nuclear fuel shipments.

A package for irradiated nuclear fuel with activity greater than 37 PBq (10⁶ Ci) must be so designed that its

undamaged containment system can withstand an external water pressure of 2 MPa (290 psi) for a period of not less than one hour without collapse, buckling, or inleakage of water.

§ 71.63 Special requirements for plutonium shipments.

(a) Plutonium in excess of 0.74 TBq (20 Ci) per package must be shipped as a solid.

(b) Plutonium in excess of 0.74 TBq (20 Ci) per package must be packaged in a separate inner container placed within outer packaging that meets the requirements of Subparts E and F of this part for packaging of material in normal form. If the entire package is subjected to the tests specified in § 71.71 ("Normal conditions of transport"), the separate inner container must not release plutonium as demonstrated to a sensitivity of 10⁻⁶ A₂/h. If the entire package is subjected to the tests specified in § 71.73 ("Hypothetical accident conditions"), the separate inner container must restrict the loss of plutonium to not more than A₂ in 1 week. Solid plutonium in the following forms is exempt from the requirements of this paragraph:

(1) Reactor fuel elements;

(2) Metal or metal alloy;

(3) Vitrified high-level waste contained in a sealed canister designed to maintain waste containment during handling activities associated with transport. As one method of meeting these design requirements, the NRC will consider acceptable a canister which is designed in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, 1995 Edition (earlier editions may be used in lieu of the 1995 Edition). However, this canister need not be designed in accordance with the requirements of Section VIII, Parts UG-46, UG-115 through UG-120, UG-125 through UG-136, UW-60, UW-65, UHA-60, and UHA-65 and the canister's final closure weld need not be designed in accordance with the requirements of Section VIII, Parts UG-99 and UW-11. The Director of the Federal Register approves this incorporation by reference in accordance with 5 U.S.C. 552(a) and 1 CFR Part 51. Copies

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of the ASME Boiler and Pressure Vessel Code, Section VIII, 1995 Edition, may be purchased from the American Society of Mechanical Engineers, Service Center, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007. It is also available for inspection at the NRC Library, 11545 Rockville Pike, Rockville, MD 20852-2738 or at the Office of the Federal Register, 800 North Capitol Street, NW., Suite 700, Washington, DC.; and

(4) Other plutonium bearing solids that the Commission determines should be exempt from the requirements of this section.

[63 FR 32605, June 15, 1998]

§ 71.64 Special requirements for plutonium air shipments.

(a) A package for the shipment of plutonium by air subject to § 71.88(a)(4), in addition to satisfying the requirements of §§ 71.41 through 71.63, as applicable, must be designed, constructed, and prepared for shipment so that under the tests specified in—

(1) Section 71.74 (“Accident conditions for air transport of plutonium”)—

(i) The containment vessel would not be ruptured in its post-tested condition, and the package must provide a sufficient degree of containment to restrict accumulated loss of plutonium contents to not more than an A₂ quantity in a period of 1 week;

(ii) The external radiation level would not exceed 10 mSv/h (1 rem/h) at a distance of 1 m (40 in) from the surface of the package in its post-tested condition in air; and

(iii) A single package and an array of packages are demonstrated to be subcritical in accordance with this part, except that the damaged condition of the package must be considered to be that which results from the plutonium accident tests in § 71.74, rather than the hypothetical accident tests in § 71.73; and

(2) Section 71.74(c), there would be no detectable leakage of water into the containment vessel of the package.

(b) With respect to the package requirements of paragraph (a), there must be a demonstration or analytical assessment showing that—

(1) The results of the physical testing for package qualification would not be

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adversely affected to a significant extent by—

(i) The presence, during the tests, of the actual contents that will be transported in the package; and

(ii) Ambient water temperatures ranging from 0.6°C (+33°F) to 38°C (+100°F) for those qualification tests involving water, and ambient atmospheric temperatures ranging from -40°C (-40°F) to +54°C (+130°F) for the other qualification tests.

(2) The ability of the package to meet the acceptance standards prescribed for the accident condition sequential tests would not be adversely affected if one or more tests in the sequence were deleted.

§ 71.65 Additional requirements.

The Commission may, by rule, regulation, or order, impose requirements on any licensee, in addition to those established in this part, as it deems necessary or appropriate to protect public health or to minimize danger to life or property.

Subpart F—Package, Special Form, and LSA-III Tests²

§ 71.71 Normal conditions of transport.

(a) *Evaluation.* Evaluation of each package design under normal conditions of transport must include a determination of the effect on that design of the conditions and tests specified in this section. Separate specimens may be used for the free drop test, the compression test, and the penetration test, if each specimen is subjected to the water spray test before being subjected to any of the other tests.

(b) *Initial conditions.* With respect to the initial conditions for the tests in this section, the demonstration of compliance with the requirements of this part must be based on the ambient temperature preceding and following the tests remaining constant at that value between -29°C (-20°F) and +38°C (+100°F) which is most unfavorable for the feature under consideration. The initial internal pressure within the

²The package standards related to the tests in this subpart are contained in subpart E of this part.

containment system must be considered to be the maximum normal operating pressure, unless a lower internal pressure consistent with the ambient temperature considered to precede and follow the tests is more unfavorable.

(c) *Conditions and tests.*

(1) *Heat.* An ambient temperature of 38°C (100°F) in still air, and insolation according to the following table:

INSOLATION DATA	
Form and location of surface	Total insolation for a 12-hour period (g cal/cm ²)
Flat surfaces transported horizontally:	
Base	None
Other surfaces	800
Flat surfaces not transported horizontally ..	200
Curved surfaces	400

(2) *Cold.* An ambient temperature of -40°C (-40°F) in still air and shade.

(3) *Reduced external pressure.* An external pressure of 25 kPa (3.5 lbf/in²) absolute.

(4) *Increased external pressure.* An external pressure of 140 kPa (20 lbf/in²) absolute.

(5) *Vibration.* Vibration normally incident to transport.

(6) *Water spray.* A water spray that simulates exposure to rainfall of approximately 5 cm/h (2 in/h) for at least 1 hour.

(7) *Free drop.* Between 1.5 and 2.5 hours after the conclusion of the water spray test, a free drop through the distance specified below onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected.

CRITERIA FOR FREE DROP TEST (WEIGHT/DISTANCE)

Package weight		Free drop distance	
Kilograms	(Pounds)	Meters	(Feet)
Less than 5,000	(Less than 11,000)	1.2	(4)
5,000 to 10,000	(11,000 to 22,000)	0.9	(3)
10,000 to 15,000 ...	(22,000 to 33,100)	0.6	(2)
More than 15,000 ..	(More than 33,100)	0.3	(1)

(8) *Corner drop.* A free drop onto each corner of the package in succession, or in the case of a cylindrical package onto each quarter of each rim, from a height of 0.3 m (1 ft) onto a flat, essentially unyielding, horizontal surface.

This test applies only to fiberboard, wood, or fissile material rectangular packages not exceeding 50 kg (110 lbs) and fiberboard, wood, or fissile material cylindrical packages not exceeding 100 kg (220 lbs).

(9) *Compression.* For packages weighing up to 5000 kg (11,000 lbs), the package must be subjected, for a period of 24 hours, to a compressive load applied uniformly to the top and bottom of the package in the position in which the package would normally be transported. The compressive load must be the greater of the following:

(i) The equivalent of 5 times the weight of the package; or

(ii) The equivalent of 13 kPa (2 lbf/in²) multiplied by the vertically projected area of the package.

(10) *Penetration.* Impact of the hemispherical end of a vertical steel cylinder of 3.2 cm (1.25 in) diameter and 6 kg (13 lbs) mass, dropped from a height of 1 m (40 in) onto the exposed surface of the package that is expected to be most vulnerable to puncture. The long axis of the cylinder must be perpendicular to the package surface.

§71.73 Hypothetical accident conditions.

(a) *Test procedures.* Evaluation for hypothetical accident conditions is to be based on sequential application of the tests specified in this section, in the order indicated, to determine their cumulative effect on a package or array of packages. An undamaged specimen may be used for the water immersion tests specified in paragraph (c)(6) of this section.

(b) *Test conditions.* With respect to the initial conditions for the tests, except for the water immersion tests, to demonstrate compliance with the requirements of this part during testing, the ambient air temperature before and after the tests must remain constant at that value between -29°C (-20°F) and +38°C (+100°F) which is most unfavorable for the feature under consideration. The initial internal pressure within the containment system must be the maximum normal operating pressure, unless a lower internal pressure, consistent with the ambient temperature assumed to precede and follow the tests, is more unfavorable.

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(c) *Tests.* Tests for hypothetical accident conditions must be conducted as follows:

(1) *Free Drop.* A free drop of the specimen through a distance of 9 m (30 ft) onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected.

(2) *Crush.* Subjection of the specimen to a dynamic crush test by positioning the specimen on a flat, essentially unyielding, horizontal surface so as to suffer maximum damage by the drop of a 500 kg (1100 pound) mass from 9 m (30 ft) onto the specimen. The mass must consist of a solid mild steel plate 1 m (40 in) by 1 m and must fall in a horizontal attitude. The crush test is required only when the specimen has a mass not greater than 500 kg (1100 lbs), an overall density not greater than 1000 kg/m³ (62.4 lbs/ft³) based on external dimensions, and radioactive contents greater than 1000 A₂ not as special form radioactive material.

(3) *Puncture.* A free drop of the specimen through a distance of 1 m (40 in) in a position for which maximum damage is expected, onto the upper end of a solid, vertical, cylindrical, mild steel bar mounted on an essentially unyielding, horizontal surface. The bar must be 15 cm (6 in) in diameter, with the top horizontal and its edge rounded to a radius of not more than 6 mm (0.25 in), and of a length as to cause maximum damage to the package, but not less than 20 cm (8 in) long. The long axis of the bar must be vertical.

(4) *Thermal.* Exposure of the specimen fully engulfed, except for a simple support system, in a hydrocarbon fuel/air fire of sufficient extent, and in sufficiently quiescent ambient conditions, to provide an average emissivity coefficient of at least 0.9, with an average flame temperature of at least 800°C (1475°F) for a period of 30 minutes, or any other thermal test that provides the equivalent total heat input to the package and which provides a time averaged environmental temperature of 800°C. The fuel source must extend horizontally at least 1 m (40 in), but may not extend more than 3 m (10 ft), beyond any external surface of the specimen, and the specimen must be positioned 1 m (40 in) above the surface

of the fuel source. For purposes of calculation, the surface absorptivity coefficient must be either that value which the package may be expected to possess if exposed to the fire specified or 0.8, whichever is greater; and the convective coefficient must be that value which may be demonstrated to exist if the package were exposed to the fire specified. Artificial cooling may not be applied after cessation of external heat input, and any combustion of materials of construction, must be allowed to proceed until it terminates naturally.

(5) *Immersion—fissile material.* For fissile material subject to §71.55, in those cases where water inleakage has not been assumed for criticality analysis, immersion under a head of water of at least 0.9 m (3 ft) in the attitude for which maximum leakage is expected.

(6) *Immersion—all packages.* A separate, undamaged specimen must be subjected to water pressure equivalent to immersion under a head of water of at least 15 m (50 ft). For test purposes, an external pressure of water of 150 kPa (21.7 lbf/in²) gauge is considered to meet these conditions.

§71.74 Accident conditions for air transport of plutonium.

(a) *Test conditions—Sequence of tests.* A package must be physically tested to the following conditions in the order indicated to determine their cumulative effect.

(1) Impact at a velocity of not less than 129 m/sec (422 ft/sec) at a right angle onto a flat, essentially unyielding, horizontal surface, in the orientation (e.g., side, end, corner) expected to result in maximum damage at the conclusion of the test sequence.

(2) A static compressive load of 31,800 kg (70,000 lbs) applied in the orientation expected to result in maximum damage at the conclusion of the test sequence. The force on the package must be developed between a flat steel surface and a 5 cm (2 in) wide, straight, solid, steel bar. The length of the bar must be at least as long as the diameter of the package, and the longitudinal axis of the bar must be parallel to the plane of the flat surface. The load must be applied to the bar in a manner that prevents any members or devices

used to support the bar from contacting the package.

(3) Packages weighing less than 227 kg (500 lbs) must be placed on a flat, essentially unyielding, horizontal surface, and subjected to a weight of 227 kg (500 lbs) falling from a height of 3 m (10 ft) and striking in the position expected to result in maximum damage at the conclusion of the test sequence. The end of the weight contacting the package must be a solid probe made of mild steel. The probe must be the shape of the frustum of a right circular cone, 30 cm (12 in) long, 20 cm (8 in) in diameter at the base, and 2.5 cm (1 in) in diameter at the end. The longitudinal axis of the probe must be perpendicular to the horizontal surface. For packages weighing 227 kg (500 lbs) or more, the base of the probe must be placed on a flat, essentially unyielding horizontal surface, and the package dropped from a height of 3 m (10 ft) onto the probe, striking in the position expected to result in maximum damage at the conclusion of the test sequence.

(4) The package must be firmly restrained and supported such that its longitudinal axis is inclined approximately 45° to the horizontal. The area of the package that made first contact with the impact surface in paragraph (a)(1) of this section must be in the lowermost position. The package must be struck at approximately the center of its vertical projection by the end of a structural steel angle section falling from a height of at least 46 m (150 ft). The angle section must be at least 1.8 m (6 ft) in length with equal legs at least 13 cm (5 in) long and 1.3 cm (0.5 in) thick. The angle section must be guided in such a way as to fall end-on, without tumbling. The package must be rotated approximately 90° about its longitudinal axis and struck by the steel angle section falling as before.

(5) The package must be exposed to luminous flames from a pool fire of JP-4 or JP-5 aviation fuel for a period of at least 60 minutes. The luminous flames must extend an average of at least 0.9 m (3 ft) and no more than 3 m (10 ft) beyond the package in all horizontal directions. The position and orientation of the package in relation to the fuel must be that which is expected to result in maximum damage at the

conclusion of the test sequence. An alternate method of thermal testing may be substituted for this fire test, provided that the alternate test is not of shorter duration and would not result in a lower heating rate to the package. At the conclusion of the thermal test, the package must be allowed to cool naturally or must be cooled by water sprinkling, whichever is expected to result in maximum damage at the conclusion of the test sequence.

(6) Immersion under at least 0.9 m (3 ft) of water.

(b) *Individual free-fall impact test.*

(1) An undamaged package must be physically subjected to an impact at a velocity not less than the calculated terminal free-fall velocity, at mean sea level, at a right angle onto a flat, essentially unyielding, horizontal surface, in the orientation (e.g., side, end, corner) expected to result in maximum damage.

(2) This test is not required if the calculated terminal free-fall velocity of the package is less than 129 m/sec (422 ft/sec), or if a velocity not less than either 129 m/sec (422 ft/sec) or the calculated terminal free-fall velocity of the package is used in the sequential test of paragraph (a)(1) of this section.

(c) *Individual deep submersion test.* An undamaged package must be physically submerged and physically subjected to an external water pressure of at least 4 MPa (600 lbs/in²).

§ 71.75 Qualification of special form radioactive material.

(a) Special form radioactive materials must meet the test requirements of paragraph (b) of this section. Each solid radioactive material or capsule specimen to be tested must be manufactured or fabricated so that it is representative of the actual solid material or capsule that will be transported, with the proposed radioactive content duplicated as closely as practicable. Any differences between the material to be transported and the test material, such as the use of non-radioactive contents, must be taken into account in determining whether the test requirements have been met. In addition:

(1) A different specimen may be used for each of the tests;

(2) The specimen may not break or shatter when subjected to the impact, percussion, or bending tests;

(3) The specimen may not melt or disperse when subjected to the heat test;

(4) After each test, leaktightness or indispersibility of the specimen must be determined by a method no less sensitive than the leaching assessment procedure prescribed in paragraph (c) of this section. For a capsule resistant to corrosion by water, and which has an internal void volume greater than 0.1 milliliter, an alternative to the leaching assessment is a demonstration of leaktightness of $\times 10^{-4}$ torr-liter/s (1.3×10^{-4} atm-cm³/s) based on air at 25°C (77°F) and one atmosphere differential pressure for solid radioactive content, or $\times 10^{-6}$ torr-liter/s (1.3×10^{-6} atm-cm³/s) for liquid or gaseous radioactive content; and

(5) A specimen that comprises or simulates radioactive material contained in a sealed capsule need not be subjected to the leaktightness procedure specified in this section, provided it is alternatively subjected to any of the tests prescribed in ISO/TR4826-1979(E), "Sealed radioactive sources leak test methods" which is available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

(b) *Test methods.* (1) *Impact Test.* The specimen must fall onto the target from a height of 9 m (30 ft) or greater in the orientation expected to result in maximum damage. The target must be a flat, horizontal surface of such mass and rigidity that any increase in its resistance to displacement or deformation, on impact by the specimen, would not significantly increase the damage to the specimen.

(2) *Percussion Test.* (i) The specimen must be placed on a sheet of lead that is supported by a smooth solid surface, and struck by the flat face of a steel billet so as to produce an impact equivalent to that resulting from a free drop of 1.4 kg (3 lbs) through 1 m (40 in);

(ii) The flat face of the billet must be 25 millimeters (mm) (1 inch) in diameter with the edges rounded off to a radius of $3 \text{ mm} \pm 0.3 \text{ mm}$ (.12 in \pm 0.012 in);

(iii) The lead must be hardness number 3.5 to 4.5 on the Vickers scale and

thickness 25 mm (1 in) or greater, and must cover an area greater than that covered by the specimen;

(iv) A fresh surface of lead must be used for each impact; and

(v) The billet must strike the specimen so as to cause maximum damage.

(3) *Bending test.* (i) This test applies only to long, slender sources with a length of 10 cm (4 inches) or greater and a length to width ratio of 10 or greater;

(ii) The specimen must be rigidly clamped in a horizontal position so that one half of its length protrudes from the face of the clamp;

(iii) The orientation of the specimen must be such that the specimen will suffer maximum damage when its free end is struck by the flat face of a steel billet;

(iv) The billet must strike the specimen so as to produce an impact equivalent to that resulting from a free vertical drop of 1.4 kg (3 lbs) through 1 m (40 in); and

(v) The flat face of the billet must be 25 mm (1 inch) in diameter with the edges rounded off to a radius of $3 \text{ mm} \pm 0.3 \text{ mm}$ (.12 in \pm 0.012 in).

(4) *Heat test.* The specimen must be heated in air to a temperature of not less than 800°C (1475°F), held at that temperature for a period of 10 minutes, and then allowed to cool.

(c) *Leaching assessment methods.* (1) For indispersible solid material—

(i) The specimen must be immersed for 7 days in water at ambient temperature. The water must have a pH of 6-8 and a maximum conductivity of 10 micromho per centimeter at 20° (68°F);

(ii) The water with specimen must then be heated to a temperature of $50^\circ\text{C} \pm 5^\circ\text{C}$ ($122^\circ\text{F} \pm 9^\circ\text{F}$) and maintained at this temperature for 4 hours.

(iii) The activity of the water must then be determined;

(iv) The specimen must then be stored for at least 7 days in still air of relative humidity not less than 90 percent at 30°C (86°F);

(v) The specimen must then be immersed in water under the same conditions as in paragraph (c)(1)(i) of this section, and the water with specimen must be heated to $50^\circ\text{C} \pm 5^\circ\text{C}$ ($122^\circ\text{F} \pm 9^\circ\text{F}$) and maintained at that temperature for 4 hours;

(vi) The activity of the water must then be determined. The sum of the activities determined here and in paragraph (c)(1)(iii) of this section must not exceed 2 kilobecquerels (kBq) (0.05 microcurie (μCi)).

(2) For encapsulated material—

(i) The specimen must be immersed in water at ambient temperature. The water must have a pH of 6–8 and a maximum conductivity of 10 micromho per centimeter;

(ii) The water and specimen must be heated to a temperature of $50^{\circ}\text{C}\pm 5^{\circ}\text{C}$ ($122^{\circ}\text{F}\pm 9^{\circ}\text{F}$) and maintained at this temperature for 4 hours;

(iii) The activity of the water must then be determined;

(iv) The specimen must then be stored for at least 7 days in still air at a temperature of 30°C (86°F) or greater;

(v) The process in paragraph (c)(2)(i), (ii), and (iii) of this section must be repeated; and

(vi) The activity of the water must then be determined. The sum of the activities determined here and in paragraph (c)(2)(iii) of this section must not exceed 2 kilobecquerels (kBq) (0.05 microcurie (μCi)).

(d) A specimen that comprises or simulates radioactive material contained in a sealed capsule need not be subjected to—

(1) The impact test and the percussion test of this section, provided that the specimen is alternatively subjected to the Class 4 impact test prescribed in ISO 2919–1980(e), “Sealed Radioactive Sources Classification” (see § 71.75(a)(5) for statement of availability); and

(2) The heat test of this section, provided the specimen is alternatively subjected to the Class 6 temperature test specified in the International Organization for Standardization document ISO 2919–1980(e), “Sealed Radioactive Sources Classification.”

§ 71.77 Qualification of LSA-III Material.

(a) LSA-III material must meet the test requirements of paragraph (b) of this section. Any differences between the specimen to be tested and the material to be transported must be taken into account in determining whether the test requirements have been met.

(b) *Leaching Test.* (1) The specimen, representing no less than the entire contents of the package, must be immersed for 7 days in water at ambient temperature;

(2) The volume of water to be used in the test must be sufficient to ensure that at the end of the test period the free volume of the unabsorbed and unreacted water remaining will be at least 10% of the volume of the specimen itself;

(3) The water must have an initial pH of 6–8 and a maximum conductivity 10 micromho/cm at 20°C (68°F); and

(4) The total activity of the free volume of water must be measured following the 7 day immersion test and must not exceed $0.1 A_2$.

Subpart G—Operating Controls and Procedures

§ 71.81 Applicability of operating controls and procedures.

A licensee subject to this part, who, under a general or specific license, transports licensed material or delivers licensed material to a carrier for transport, shall comply with the requirements of this subpart G, with the quality assurance requirements of subpart H of this part, and with the general provisions of subpart A of this part.

§ 71.83 Assumptions as to unknown properties.

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.

§ 71.85 Preliminary determinations.

Before the first use of any packaging for the shipment of licensed material—

(a) The licensee shall ascertain that there are no cracks, pinholes, uncontrolled voids, or other defects that could significantly reduce the effectiveness of the packaging;

(b) Where the maximum normal operating pressure will exceed 35 kPa (5 lbf/in²) gauge, the licensee shall test the containment system at an internal

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pressure at least 50 percent higher than the maximum normal operating pressure, to verify the capability of that system to maintain its structural integrity at that pressure; and

(c) The licensee shall conspicuously and durably mark the packaging with its model number, serial number, gross weight, and a package identification number assigned by NRC. Before applying the model number, the licensee shall determine that the packaging has been fabricated in accordance with the design approved by the Commission.

§ 71.87 Routine determinations.

Before each shipment of licensed material, the licensee shall ensure that the package with its contents satisfies the applicable requirements of this part and of the license. The licensee shall determine that—

(a) The package is proper for the contents to be shipped;

(b) The package is in unimpaired physical condition except for superficial defects such as marks or dents;

(c) Each closure device of the packaging, including any required gasket, is properly installed and secured and free of defects;

(d) Any system for containing liquid is adequately sealed and has adequate space or other specified provision for expansion of the liquid;

(e) Any pressure relief device is operable and set in accordance with written procedures;

(f) The package has been loaded and closed in accordance with written procedures;

(g) For fissile material, any moderator or neutron absorber, if required, is present and in proper condition;

(h) 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 § 71.45;

(i) 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 DOT regulations in 49 CFR 173.443;

(j) External radiation levels around the package and around the vehicle, if

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applicable, will not exceed the limits specified in § 71.47 at any time during transportation; and

(k) Accessible package surface temperatures will not exceed the limits specified in § 71.43(g) at any time during transportation.

§ 71.88 Air transport of plutonium.

(a) Notwithstanding the provisions of any general licenses and notwithstanding any exemptions stated directly in this part 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 not greater than 0.002 μ Ci/g (70 Bq/g) of material and in which the radioactivity is essentially uniformly distributed; or

(3) The plutonium is shipped in a single package containing no more than an A₂ quantity of plutonium in any isotope or form, and is shipped in accordance with § 71.5; 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 Commission.

(b) Nothing in paragraph (a) of this section is to be interpreted as removing or diminishing the requirements of § 73.24 of this chapter.

(c) For a shipment of plutonium by air which is subject to paragraph (a)(4) of this section, 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.

§ 71.89 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

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been sent to, or otherwise made available to, the consignee for the consignee's use in accordance with 10 CFR 20.1906(e).

§ 71.91 Records.

(a) Each licensee shall maintain, for a period of 3 years after shipment, a record of each shipment of licensed material not exempt under § 71.10, 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 § 71.87 and by the conditions of the package approval.

(b) The licensee shall make available to the Commission for inspection, upon reasonable notice, all records required by this part. Records are only valid if stamped, initialed, or signed and dated by authorized personnel or otherwise authenticated.

(c) 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 § 71.85; design, fabrication, and assembly records, results of reviews, inspections, tests, and audits; results of monitoring work performance and mate-

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

§ 71.93 Inspection and tests.

(a) The licensee or certificate holder shall permit the Commission, at all reasonable times, to inspect the licensed material, packaging, premises, and facilities in which the licensed material or packaging is used, provided, constructed, fabricated, tested, stored, or shipped.

(b) The licensee shall perform, and permit the Commission to perform, any tests the Commission deems necessary or appropriate for the administration of the regulations in this chapter.

(c) The licensee shall notify the Administrator of the appropriate NRC Regional Office listed in appendix A of part 73 of this chapter, 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.

§ 71.95 Reports.

The licensee shall report to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, 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.

§ 71.97 Advance notification of shipment of irradiated reactor fuel and nuclear waste.

(a) As specified in paragraphs (b), (c) and (d) of this section, each licensee shall provide advance notification to the governor of a State, or the governor's designee, 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 for shipments of irradiated reactor fuel in quantities less than that subject to advance notification requirements of § 73.37(f) of this chapter. Advance notification is also required under this section for shipment of licensed material, other than irradiated fuel, meeting the following three conditions:

(1) The licensed material is required by this part to be in Type B packaging for transportation;

(2) The licensed material is being transported to or across a 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 appendix A, Table A-1 for special form radioactive material;

(ii) 3000 times the A_2 value of the radionuclides as specified in appendix A, Table A-1 for normal form radioactive material; or

(iii) 1000 TBq (27,000 Ci).

(c) *Procedures for submitting advance notification.* (1) The notification must be made in writing to the office of each appropriate governor or governor's designee and to the Administrator of the appropriate NRC Regional Office listed in appendix A to part 73 of this chapter.

(2) A notification delivered by mail must be postmarked at least 7 days before the beginning of the 7-day period during which departure of the shipment is estimated to occur.

(3) A notification delivered by messenger must reach the office of the gov-

ernor or of the governor's designee at least 4 days before the beginning of the 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.

(4) The licensee shall retain a copy of the notification as a record for 3 years.

(d) *Information to be furnished in advance notification of shipment.* Each advance notification of shipment of irradiated reactor fuel or nuclear waste must 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 DOT in 49 CFR 172.202 and 172.203(d);

(3) The point of origin of the shipment and the 7-day period during which departure of the shipment is estimated to occur;

(4) The 7-day period during which arrival of the shipment at State boundaries is estimated to occur;

(5) The destination of the shipment, and the 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 a governor or governor's designee, in accordance with this section, 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 inform

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that individual 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 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 Administrator of the appropriate NRC Regional Office listed in appendix A of part 73 of this chapter.

(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 3 years.

§ 71.99 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of—

(1) The Atomic Energy Act of 1954, as amended;

(2) Title II of the Energy Reorganization Act of 1974, as amended; or (3) A regulation or order issued pursuant to those Acts.

(b) The Commission may obtain a court order for the payment of a civil penalty imposed under section 234 of the Atomic Energy Act:

(1) For violations of—

(i) Sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;

(ii) Section 206 of the Energy Reorganization Act;

(iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section; or

(iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.

(2) For any violation for which a license may be revoked under section 186 of the Atomic Energy Act of 1954, as amended.

§ 71.100 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation

of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161o of the Act. For purposes of section 223, all the regulations in part 71 are issued under one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) of this section.

(b) The regulations in part 71 that are not issued under sections 161b, 161i, or 161o for the purposes of section 223 are as follows: §§ 71.0, 71.2, 71.4, 71.6, 71.7, 71.9, 71.10, 71.31, 71.33, 71.35, 71.37, 71.38, 71.39, 71.41, 71.43, 71.45, 71.47, 71.51, 71.52, 71.53, 71.55, 71.59, 71.65, 71.71, 71.73, 71.74, 71.75, 71.77, 71.99, and 71.100.

Subpart H—Quality Assurance

§ 71.101 Quality assurance requirements.

(a) *Purpose.* This subpart 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 subpart, “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.

(b) *Establishment of program.* Each licensee shall establish, maintain, and execute a quality assurance program satisfying each of the applicable criteria of §§ 71.101 through 71.137 and satisfying any specific provisions that are applicable to the licensee's activities including procurement of packaging. The licensee shall apply each of the applicable criteria in a graded approach, i.e., to an extent that is consistent with its importance to safety.

(c) *Approval of program.* Before the use of any package for the shipment of licensed material subject to this subpart, each licensee shall obtain Commission approval of its quality assurance program. Each licensee shall file a description of its quality assurance

program, including a discussion of which requirements of this subpart are applicable and how they will be satisfied, with the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

(d) *Existing package designs.* The provisions of this paragraph deal with packages that have been approved for use in accordance with this part before January 1, 1979, and which have been designed in accordance with the provisions of this part in effect at the time of application for package approval. Those packages will be accepted as having been designed in accordance with a quality assurance program that satisfies the provisions of paragraph (b) of this section.

(e) *Existing packages.* The provisions of this paragraph deal with packages that have been approved for use in accordance with this part before January 1, 1979; have been at least partially fabricated prior to that date; and for which the fabrication is in accordance with the provisions of this part in effect at the time of application for approval of package design. These packages will be accepted as having been fabricated and assembled in accordance with a quality assurance program that satisfies the provisions of paragraph (b) of this section.

(f) *Previously approved programs.* A Commission-approved quality assurance program that satisfies the applicable criteria of Appendix B of Part 50 of this chapter, and that is established, maintained, and executed with regard to transport packages, will be accepted as satisfying the requirements of paragraph (b) of this section. Before first use, the licensee shall notify the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, of its intent to apply its previously approved Appendix B program to transportation activities. The licensee shall identify the program by date of submittal to the Commission, Docket Number, and date of Commission approval.

(g) *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 §34.31(b) or equivalent Agreement State requirement, is deemed to satisfy the requirements of §71.12(b) and 71.101(b) of this chapter.

[60 FR 50264, Sept. 28, 1995, as amended at 62 FR 28973, May 28, 1997]

§71.103 Quality assurance organization.

(a) The licensee³ shall be responsible for the establishment and execution of the quality assurance program. The licensee may delegate to others, such as contractors, agents, or consultants, the work of establishing and executing the quality assurance program, or any part of the quality assurance program, but shall retain responsibility for the program. The licensee shall clearly establish and delineate, in writing, the authority and duties of persons and organizations performing activities affecting the safety-related functions of structures, systems, and components. These activities include performing the functions associated with attaining quality objectives and the quality assurance functions.

(b) The quality assurance functions are—

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

(2) Verifying, by procedures such as checking, auditing, and inspection, that activities affecting the safety-related functions have been performed correctly.

(c) The persons and organizations performing quality assurance functions must have sufficient authority and organizational freedom to—

(1) Identify quality problems;

(2) Initiate, recommend, or provide solutions; and

(3) Verify implementation of solutions.

(d) The persons and organizations performing quality assurance functions shall report to a management level

³While 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 prior to the time a package approval is issued.

that assures that the required authority and organizational freedom, including sufficient independence from cost and schedule, when opposed to safety considerations, are provided.

(e) Because of the many variables involved, such as the number of personnel, the type of activity being performed, and the location or locations where activities are performed, the organizational structure for executing the quality assurance program may take various forms, provided that the persons and organizations assigned the quality assurance functions have the required authority and organizational freedom.

(f) Irrespective of the organizational structure, the individual(s) assigned the responsibility for assuring effective execution of any portion of the quality assurance program, at any location where activities subject to this section are being performed, must have direct access to the levels of management necessary to perform this function.

§ 71.105 Quality assurance program.

(a) The licensee 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 §§ 71.101 through 71.137. The licensee 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 shall identify the material and components to be covered by the quality assurance program, the major organizations participating in the program, and the designated functions of these organizations.

(b) The licensee, through its quality assurance program, 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 shall assure that activities affecting quality are accomplished under suitably controlled conditions. Controlled condi-

tions 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 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.

(c) The licensee 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:

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

(d) The licensee 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 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 which they are executing.

§ 71.107 Package design control.

(a) The licensee shall establish measures to assure that applicable regulatory requirements and the package design, as specified in the license for those materials and components to which this section applies, are correctly translated into specifications, drawings, procedures, and instructions. These measures must include provisions to assure that appropriate quality standards are specified and included in design documents and that deviations from standards are controlled.

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Measures must be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the materials, parts, and components of the packaging.

(b) The licensee shall establish measures for the identification and control of design interfaces and for coordination among participating design organizations. These measures must include the establishment of written procedures, among participating design organizations, for the review, approval, release, distribution, and revision of documents involving design interfaces. The design control measures must provide for verifying or checking the adequacy of design, by methods such as design reviews, alternate or simplified calculational methods, or by a suitable testing program. For the verifying or checking process, the licensee shall designate individuals or groups other than those who were responsible for the original design, but who may be from the same organization. Where a test program is used to verify the adequacy of a specific design feature in lieu of other verifying or checking processes, the licensee shall include suitable qualification testing of a prototype or sample unit under the most adverse design conditions. The licensee shall apply design control measures to items such as the following:

- (1) Criticality physics, radiation shielding, stress, thermal, hydraulic, and accident analyses;
- (2) Compatibility of materials;
- (3) Accessibility for inservice inspection, maintenance, and repair;
- (4) Features to facilitate decontamination; and
- (5) Delineation of acceptance criteria for inspections and tests.

(c) The licensee shall subject design changes, including field changes, to design control measures commensurate with those applied to the original design. Changes in the conditions specified in the package approval require NRC approval.

§ 71.109 Procurement document control.

The licensee shall establish measures to assure that adequate quality is re-

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quired in the documents for procurement of material, equipment, and services, whether purchased by the licensee or by its contractors or subcontractors. To the extent necessary, the licensee shall require contractors or subcontractors to provide a quality assurance program consistent with the applicable provisions of this part.

§ 71.111 Instructions, procedures, and drawings.

The licensee shall prescribe activities affecting quality by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall require that these instructions, procedures, and drawings be followed. The instructions, procedures, and drawings must include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished.

§ 71.113 Document control.

The licensee shall establish measures to control the issuance of documents such as instructions, procedures, and drawings, including changes, which prescribe all activities affecting quality. These measures must assure that documents, including changes, are reviewed for adequacy, approved for release by authorized personnel, and distributed and used at the location where the prescribed activity is performed. These measures must assure that changes to documents are reviewed and approved.

§ 71.115 Control of purchased material, equipment, and services.

(a) The licensee shall establish measures to assure that purchased material, equipment, and services, whether purchased directly or through contractors and subcontractors, conform to the procurement documents. These measures must include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products on delivery.

(b) The licensee shall have available documentary evidence that material

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and equipment conform to the procurement specifications before installation or use of the material and equipment. The licensee shall retain, or have available, this documentary evidence for the life of the package to which it applies. The licensee shall assure that the evidence is sufficient to identify the specific requirements met by the purchased material and equipment.

(c) The licensee shall assess the effectiveness of the control of quality by contractors and subcontractors at intervals consistent with the importance, complexity, and quantity of the product or services.

§ 71.117 Identification and control of materials, parts, and components.

The licensee shall establish measures for the identification and control of materials, parts, and components. These measures must assure that identification of the item is maintained by heat number, part number, or other appropriate means, either on the item or on records traceable to the item, as required throughout fabrication, installation, and use of the item. These identification and control measures must be designed to prevent the use of incorrect or defective materials, parts, and components.

§ 71.119 Control of special processes.

The licensee shall establish measures to assure that special processes, including welding, heat treating, and non-destructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

§ 71.121 Internal inspection.

The licensee shall establish and execute a program for inspection of activities affecting quality by or for the organization performing the activity, to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity. The inspection must be performed by individuals other than those who performed the activity being inspected. Examination, measurements, or tests of material or products processed must be performed for each work operation

where necessary to assure quality. If direct inspection of processed material or products is not carried out, indirect control by monitoring processing methods, equipment, and personnel must be provided. Both inspection and process monitoring must be provided when quality control is inadequate without both. If mandatory inspection hold points, which require witnessing or inspecting by the licensee's designated representative and beyond which work should not proceed without the consent of its designated representative, are required, the specific hold points must be indicated in appropriate documents.

§ 71.123 Test control.

The licensee shall establish a test program to assure that all testing required to demonstrate that the packaging components will perform satisfactorily in service is identified and performed in accordance with written test procedures that incorporate the requirements of this part and the requirements and acceptance limits contained in the package approval. The test procedures must include provisions for assuring that all prerequisites for the given test are met, that adequate test instrumentation is available and used, and that the test is performed under suitable environmental conditions. The licensee shall document and evaluate the test results to assure that test requirements have been satisfied.

§ 71.125 Control of measuring and test equipment.

The licensee shall establish measures to assure that tools, gauges, instruments, and other measuring and testing devices used in activities affecting quality are properly controlled, calibrated, and adjusted at specified times to maintain accuracy within necessary limits.

§ 71.127 Handling, storage, and shipping control.

The licensee 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.

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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.

§ 71.129 Inspection, test, and operating status.

(a) The licensee 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.

(b) The licensee shall establish measures to identify the operating status of components of the packaging, such as tagging valves and switches, to prevent inadvertent operation.

§ 71.131 Nonconforming materials, parts, or components.

The licensee 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.

§ 71.133 Corrective action.

The licensee 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 re-

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ported to appropriate levels of management.

§ 71.135 Quality assurance records.

The licensee shall maintain sufficient written records to describe the activities affecting quality. The records must include the instructions, procedures, and drawings required by § 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 shall retain these records for 3 years beyond the date when the licensee last engages in the activity for which the quality assurance program was developed. If any portion of the written procedures or instructions is superseded, the licensee shall retain the superseded material for 3 years after it is superseded.

§ 71.137 Audits.

The licensee 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 reaudit of deficient areas, must be taken where indicated.

APPENDIX A TO PART 71— DETERMINATION OF A₁ AND A₂

I. 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 one tenth of one percent

or less. Where values of A_1 or A_2 are unlimited, it is for radiation control purposes only. For nuclear criticality safety, some materials are subject to controls placed on fissile material.

II. For individual radionuclides whose identities are known, but which are not listed in Table A-1, the determination of the values of A_1 and A_2 requires Commission approval, except that the values of A_1 and A_2 in Table A-2 may be used without obtaining Commission approval.

III. In the calculations of A_1 and A_2 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 10 days, or longer than that of the parent nuclide, shall be considered as a single radionuclide, and the activity to be taken into account, and the A_1 or A_2 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 10 days, or greater than that of the parent nuclide, the parent and those daughter nuclides shall be considered as mixtures of different nuclides.

IV. 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:

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

(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 $A_1(i)$ and $A_2(i)$ are the A_1 and A_2 values for radionuclide I, respectively.

Alternatively, an A_1 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 $A_1(i)$ is the appropriate A_1 value for nuclide I.

An A_2 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 $A_2(i)$ is the appropriate A_2 value for nuclide I.

V. When the identity of each radionuclide is known, but the individual activities of some of the radionuclides are not known, the radionuclides may be grouped and the lowest A_1 or A_2 value, as appropriate, for the radionuclides in each group may be used in applying the formulas in paragraph IV. 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.—A₁ AND A₂ VALUES FOR RADIONUCLIDES

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
Ac-225	Actinium(89)	0.6	16.2	1×10 ⁻²	0.270	2.1×10 ³	5.8×10 ⁴
Ac-227		40	1080	2×10 ⁻⁵	5.41×10 ⁻⁴	2.7	7.2×10 ¹
Ac-228	Silver(47)	0.6	16.2	0.4	10.8	8.4×10 ⁴	2.2×10 ⁶
Ag-105		2	54.1	2	54.1	1.1×10 ³	3.0×10 ⁴
Ag-108m	Silver(47)	0.6	16.2	0.6	16.2	9.7×10 ⁻¹	2.6×10 ¹
Ag-110m		0.4	10.8	0.4	10.8	1.8×10 ²	4.7×10 ³
Ag-111	Aluminum(13)	0.6	16.2	0.5	13.5	5.8×10 ³	1.6×10 ⁵
Al-26		0.4	10.8	0.4	10.8	7.0×10 ⁻⁴	1.9×10 ⁻²
Am-241	Americium(95)	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	1.3×10 ⁻¹	3.4
Am-242m		2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	3.6×10 ⁻¹	1.0×10 ¹
Am-243	Americium(95)	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	7.4×10 ⁻³	2.0×10 ⁻¹
Ar-37		Argon(18)	40	1080	40	1080	3.7×10 ³
Ar-39	20		541	20	541	1.3	3.4×10 ¹
Ar-41	Argon(18)	0.6	16.2	0.6	16.2	1.5×10 ⁶	4.2×10 ⁷
Ar-42		0.2	5.41	0.2	5.41	9.6	2.6×10 ²
As-72	Arsenic(33)	0.2	5.41	0.2	5.41	6.2×10 ⁴	1.7×10 ⁶
As-73		40	1080	40	1080	8.2×10 ²	2.2×10 ⁴
As-74	Arsenic(33)	1	27.0	0.5	13.5	3.7×10 ³	9.9×10 ⁴
As-76		0.2	5.41	0.2	5.41	5.8×10 ⁴	1.6×10 ⁶
As-77	Arsenic(33)	20	541	0.5	13.5	3.9×10 ⁴	1.0×10 ⁶
At-211		Astatine(85)	30	811	2	54.1	7.6×10 ⁴
Au-193	Gold(79)	6	162	6	162	3.4×10 ⁴	9.2×10 ⁵
Au-194		1	27.0	1	27.0	1.5×10 ⁴	4.1×10 ⁵
Au-195	Gold(79)	10	270	10	270	1.4×10 ²	3.7×10 ³
Au-196		2	54.1	2	54.1	4.0×10 ³	1.1×10 ⁵
Au-198	Gold(79)	3	81.1	0.5	13.5	9.0×10 ³	2.4×10 ⁵
Au-199		10	270	0.9	24.3	7.7×10 ³	2.1×10 ⁵
Ba-131	Barium(56)	2	54.1	2	54.1	3.1×10 ³	8.4×10 ⁴
Ba-133m		10	270	0.9	24.3	2.2×10 ⁴	6.1×10 ⁵
Ba-133	Barium(56)	3	81.1	3	81.1	9.4	2.6×10 ²
Ba-140		0.4	10.8	0.4	10.8	2.7×10 ³	7.3×10 ⁴
Be-7	Beryllium(4)	20	541	20	541	1.3×10 ⁴	3.5×10 ⁵
Be-10		20	541	0.5	13.5	8.3×10 ⁻⁴	2.2×10 ⁻²
Bi-205	Bismuth(83)	0.6	16.2	0.6	16.2	1.5×10 ⁻³	4.2×10 ⁴
Bi-206		0.3	8.11	0.3	8.11	3.8×10 ³	1.0×10 ⁵
Bi-207	Bismuth(83)	0.7	18.9	0.7	18.9	1.9	5.2×10 ¹
Bi-210m		0.3	8.11	3×10 ⁻²	0.811	2.1×10 ⁻⁵	5.7×10 ⁻⁴
Bi-210	Bismuth(83)	0.6	16.2	0.5	13.5	4.6×10 ³	1.2×10 ⁵
Bi-212		0.3	8.11	0.3	8.11	5.4×10 ⁵	1.5×10 ⁷
Bk-247	Berkelium(97)	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	3.8×10 ⁻²	1.0
Bk-249		40	1080	8×10 ⁻²	2.16	6.1×10 ¹	1.6×10 ³
Br-76	Bromine(35)	0.3	8.11	0.3	8.11	9.4×10 ⁴	2.5×10 ⁶
Br-77		3	81.1	3	81.1	2.6×10 ⁴	7.1×10 ⁵
Br-82	Bromine(35)	0.4	10.8	0.4	10.8	4.0×10 ⁴	1.1×10 ⁶

C-11	1	27	0.5	13.5	3.1×10 ⁷	8.4×10 ⁸
C-14	40	1080	2	54.1	1.6×10 ⁻¹	4.5
Ca-41	40	1080	40	1080	3.1×10 ⁻³	8.5×10 ⁻²
Ca-45	40	1080	0.9	24.3	6.6×10 ²	1.8×10 ⁴
Ca-47	0.9	24.3	0.5	13.5	2.3×10 ⁴	6.1×10 ⁵
Cd-109	40	1080	1	27.0	9.6×10 ¹	2.6×10 ³
Cd-113m	20	541	9×10 ⁻²	2.43	8.3	2.2×10 ²
Cd-115m	0.3	8.11	0.3	8.11	9.4×10 ²	2.5×10 ⁴
Cd-115	4	108	0.5	13.5	1.9×10 ⁴	5.1×10 ⁵
Ce-139	6	162	6	162	2.5×10 ²	6.8×10 ³
Ce-141	10	270	0.5	13.5	1.1×10 ³	2.8×10 ⁴
Ce-143	0.6	16.2	0.5	13.5	2.5×10 ⁴	6.6×10 ⁵
Ce-144	0.2	5.41	0.2	5.41	1.2×10 ²	3.2×10 ³
Cf-248	30	811	3×10 ⁻³	8.11×10 ⁻²	5.8×10 ¹	1.6×10 ³
Cf-249	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	1.5×10 ⁻¹	4.1
Cf-250	5	135	5×10 ⁻⁴	1.35×10 ⁻²	4.0	1.1×10 ²
Cf-251	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	5.9×10 ⁻²	1.6
Cf-252	0.1	2.70	1×10 ⁻³	2.70×10 ⁻²	2.0×10 ¹	5.4×10 ²
Cf-253	40	1080	6×10 ⁻²	1.62	1.1×10 ³	2.9×10 ⁴
Cf-254	3×10 ⁻³	8.11×10 ⁻²	6×10 ⁻⁴	1.62×10 ⁻²	3.1×10 ²	8.5×10 ³
Cl-36	20	541	0.5	13.5	1.2×10 ⁻³	3.3×10 ⁻²
Cl-38	0.2	5.41	0.2	5.41	4.9×10 ⁶	1.3×10 ⁸
Cm-240	40	1080	2×10 ⁻²	0.541	7.5×10 ²	2.0×10 ⁴
Cm-241	2	54.1	0.9	24.3	6.1×10 ²	1.7×10 ⁴
Cm-242	40	1080	1×10 ⁻²	0.270	1.2×10 ²	3.3×10 ³
Cm-243	3	81.1	3×10 ⁻⁴	8.11×10 ⁻³	1.9	5.2×10 ¹
Cm-244	4	108	4×10 ⁻⁴	1.08×10 ⁻²	3.0	8.1×10 ¹
Cm-245	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	6.4×10 ⁻³	1.7×10 ⁻¹
Cm-246	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	1.1×10 ⁻²	3.1×10 ⁻¹
Cm-247	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	3.4×10 ⁻⁶	9.3×10 ⁻⁵
Cm-248	4×10 ⁻²	1.08	5×10 ⁻⁵	1.35×10 ⁻³	1.6×10 ⁻⁴	4.2×10 ⁻³
Co-55	0.5	13.5	0.5	13.5	1.1×10 ⁵	3.1×10 ⁶
Co-56	0.3	8.11	0.3	8.11	1.1×10 ³	3.0×10 ⁴
Co-57	8	216	8	216	3.1×10 ²	8.4×10 ³
Co-58m	40	1080	40	1080	2.2×10 ⁵	5.9×10 ⁶
Co-58	1	27.0	1	27.0	1.2×10 ³	3.2×10 ⁴
Co-60	0.4	10.8	0.4	10.8	4.2×10 ¹	1.1×10 ³
Cr-51	30	811	30	811	3.4×10 ³	9.2×10 ⁴
Cs-129	4	108	4	108	2.8×10 ⁴	7.6×10 ⁵
Cs-131	40	1080	40	1080	3.8×10 ³	1.0×10 ⁵
Cs-132	1	27.0	1	27.0	5.7×10 ³	1.5×10 ⁵
Cs-134m	40	1080	9	243	3.0×10 ⁵	8.0×10 ⁶
Cs-134	0.6	16.2	0.5	13.5	4.8×10 ¹	1.3×10 ³
Cs-135	40	1080	0.9	24.3	4.3×10 ⁻⁵	1.2×10 ⁻³
Cs-136	0.5	13.5	0.5	13.5	2.7×10 ³	7.3×10 ⁴
Cs-137	2	54.1	0.5	13.5	3.2	8.7×10 ¹
Cu-64	5	135	0.9	24.3	1.4×10 ⁵	3.9×10 ⁶
Cu-67	9	243	0.9	24.3	2.8×10 ⁴	7.6×10 ⁵
Dy-159	20	541	20	541	2.1×10 ²	5.7×10 ³
Dy-165	0.6	16.2	0.5	13.5	3.0×10 ⁵	8.2×10 ⁶
Carbon(6)	1	27	0.5	13.5	3.1×10 ⁷	8.4×10 ⁸
Calcium(20)	40	1080	40	1080	3.1×10 ⁻³	8.5×10 ⁻²
Cadmium(48)	40	1080	1	27.0	9.6×10 ¹	2.6×10 ³
Cerium(58)	6	162	6	162	2.5×10 ²	6.8×10 ³
Californium(98)	30	811	3×10 ⁻³	8.11×10 ⁻²	5.8×10 ¹	1.6×10 ³
Chlorine(17)	20	541	0.5	13.5	1.2×10 ⁻³	3.3×10 ⁻²
Curium(96)	40	1080	2×10 ⁻²	0.541	7.5×10 ²	2.0×10 ⁴
Cobalt(27)	0.5	13.5	0.5	13.5	1.1×10 ⁵	3.1×10 ⁶
Chromium(24)	30	811	30	811	3.4×10 ³	9.2×10 ⁴
Cesium(55)	4	108	4	108	2.8×10 ⁴	7.6×10 ⁵
Copper(29)	5	135	0.9	24.3	1.4×10 ⁵	3.9×10 ⁶
Dysprosium(66)	20	541	20	541	2.1×10 ²	5.7×10 ³

TABLE A-1.—A₁ AND A₂ VALUES FOR RADIONUCLIDES—Continued

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
Dy-166		0.3	8.11	0.3	8.11	8.6×10 ³	2.3×10 ⁵
Er-169	Erbium(68)	40	1080	0.9	24.3	3.1×10 ³	8.3×10 ⁴
Er-171		0.6	16.2	0.5	13.5	9.0×10 ⁴	2.4×10 ⁶
Es-253	Einsteinium(99) ^a	200	5400	2×10 ⁻²	5.41×10 ⁻¹		
Es-254		30	811	3×10 ⁻³	8.11×10 ⁻²		
Es-254m		0.6	16.2	0.4	10.8		
Es-255							
Eu-147	Europium(63)	2	54.1	2	54.1	1.4×10 ³	3.7×10 ⁴
Eu-148		0.5	13.5	0.5	13.5	6.0×10 ²	1.6×10 ⁴
Eu-149		20	541	20	541	3.5×10 ²	9.4×10 ³
Eu-150		0.7	18.9	0.7	18.9	6.1×10 ⁴	1.6×10 ⁶
Eu-152m		0.6	16.2	0.5	13.5	8.2×10 ⁴	2.2×10 ⁶
Eu-152		0.9	24.3	0.9	24.3	6.5	1.8×10 ²
Eu-154		0.8	21.6	0.5	13.5	9.8	2.6×10 ²
Eu-155		20	541	2	54.1	1.8×10 ¹	4.9×10 ²
Eu-156		0.6	16.2	0.5	13.5	2.0×10 ³	5.5×10 ⁴
F-18	Fluorine(9)	1	27.0	0.5	13.5	3.5×10 ⁶	9.5×10 ⁷
Fe-52	Iron(26)	0.2	5.41	0.2	5.41	2.7×10 ⁵	7.3×10 ⁶
Fe-55		40	1080	40	1080	8.8×10 ¹	2.4×10 ³
Fe-59		0.8	21.6	0.8	21.6	1.8×10 ³	5.0×10 ⁴
Fe-60		40	1080	0.2	5.41	7.4×10 ⁻⁴	2.0×10 ⁻²
Fm-255	Fermium(100) ^b	40	1080	0.8	21.6		
Fm-257		10	270	8×10 ⁻³	2.16×10 ⁻¹		
Ga-67	Gallium(31)	6	162	6	162	2.2×10 ⁴	6.0×10 ⁵
Ga-68		0.3	8.11	0.3	8.11	1.5×10 ⁶	4.1×10 ⁷
Ga-72		0.4	10.8	0.4	10.8	1.1×10 ⁵	3.1×10 ⁶
Gd-146	Gadolinium(64)	0.4	10.8	0.4	10.8	6.9×10 ²	1.9×10 ⁴
Gd-148		3	81.1	3×10 ⁻⁴	8.11×10 ⁻³	1.2	3.2×10 ¹
Gd-153		10	270	5	135	1.3×10 ²	3.5×10 ³
Gd-159		4	108	0.5	13.5	3.9×10 ⁴	1.1×10 ⁶
Ge-68	Germanium(32)	0.3	8.11	0.3	8.11	2.6×10 ²	7.1×10 ³
Ge-71		40	1080	40	1080	5.8×10 ³	1.6×10 ⁵
Ge-77		0.3	8.11	0.3	8.11	1.3×10 ⁵	3.6×10 ⁶
H-3	Hydrogen(1)	See T-Tritium					
Hf-172	Hafnium(72)	0.5	13.5	0.3	8.11	4.1×10 ¹	1.1×10 ³
Hf-175		3	81.1	3	81.1	3.9×10 ²	1.1×10 ⁴
Hf-181		2	54.1	0.9	24.3	6.3×10 ²	1.7×10 ⁴
Hf-182		4	108	3×10 ⁻²	0.811	8.1×10 ⁻⁶	2.2×10 ⁻⁴
Hg-194	Mercury(80)	1	27.0	1	27.0	1.3×10 ⁻¹	3.5
Hg-195m		5	135	5	135	1.5×10 ⁴	4.0×10 ⁵
Hg-197m		10	270	0.9	24.3	2.5×10 ⁴	6.7×10 ⁵
Hg-197		10	270	10	270	9.2×10 ³	2.5×10 ⁵
Hg-203		4	108	0.9	24.3	5.1×10 ²	1.4×10 ⁴
Ho-163	Holmium(67)	40	1080	40	1080	2.7	7.6×10 ¹

Ho-166m		0.6	16.2	0.3	8.11	6.6×10^{-2}	1.8
Ho-166		0.3	8.11	0.3	8.11	2.6×10^4	7.0×10^5
I-123	Iodine(53)	6	162	6	162	7.1×10^4	1.9×10^6
I-124		0.9	24.3	0.9	24.3	9.3×10^3	2.5×10^5
I-125		20	541	2	54.1	6.4×10^2	1.7×10^4
I-126		2	54.1	0.9	24.3	2.9×10^3	8.0×10^4
I-129		Unlimited	Unlimited	Unlimited	Unlimited	6.5×10^{-6}	1.8×10^{-4}
I-131		3	81.1	0.5	13.5	4.6×10^3	1.2×10^5
I-132		0.4	10.8	0.4	10.8	3.8×10^5	1.0×10^7
I-133		0.6	16.2	0.5	13.5	4.2×10^4	1.1×10^6
I-134		0.3	8.11	0.3	8.11	9.9×10^5	2.7×10^7
I-135		0.6	16.2	0.5	13.5	1.3×10^5	3.5×10^6
In-111	Indium(49)	2	54.1	2	54.1	1.5×10^4	4.2×10^5
In-113m		4	108	4	108	6.2×10^5	1.7×10^7
In-114m		0.3	8.11	0.3	8.11	8.6×10^2	2.3×10^4
In-115m		6	162	0.9	24.3	2.2×10^5	6.1×10^6
Ir-189	Iridium(77)	10	270	10	270	1.9×10^3	5.2×10^4
Ir-190		0.7	18.9	0.7	18.9	2.3×10^3	6.2×10^4
Ir-192		1	27.0	0.5	13.5	3.4×10^2	9.2×10^3
Ir-193m		10	270	10	270	2.4×10^3	6.4×10^4
Ir-194		0.2	5.41	0.2	5.41	3.1×10^4	8.4×10^5
K-40	Potassium(19)	0.6	16.2	0.6	16.2	2.4×10^{-7}	6.4×10^{-6}
K-42		0.2	5.41	0.2	5.41	2.2×10^5	6.0×10^6
K-43		1.0	27.0	0.5	13.5	1.2×10^5	3.3×10^6
Kr-81	Krypton(36)	40	1080	40	1080	7.8×10^{-4}	2.1×10^{-2}
Kr-85m		6	162	6	162	3.0×10^5	8.2×10^6
Kr-85		20	541	10	270	1.5×10^1	3.9×10^2
Kr-87		0.2	5.41	0.2	5.41	1.0×10^6	2.8×10^7
La-137	Lanthanum(57)	40	1080	2	54.1	1.6×10^{-3}	4.4×10^{-2}
La-140		0.4	10.8	0.4	10.8	2.1×10^4	5.6×10^5
Lu-172	Lutetium(71)	0.5	13.5	0.5	13.5	4.2×10^3	1.1×10^5
Lu-173		8	216	8	216	5.6×10^1	1.5×10^3
Lu-174m		20	541	8	216	2.0×10^2	5.3×10^3
Lu-174		8	216	4	108	2.3×10^1	6.2×10^2
Lu-177		30	811	0.9	24.3	4.1×10^3	1.1×10^5
MFP							
Mg-28	Magnesium(12)	0.2	5.41	0.2	5.41	2.0×10^5	5.4×10^6
Mn-52	Manganese(25)	0.3	8.11	0.3	8.11	1.6×10^4	4.4×10^5
Mn-53		Unlimited	Unlimited	Unlimited	Unlimited	6.8×10^{-5}	1.8×10^{-3}
Mn-54		1	27.0	1	27.0	2.9×10^2	7.7×10^3
Mn-56		0.2	5.41	0.2	5.41	8.0×10^5	2.2×10^7
Mo-93	Molybdenum(42)	40	1080	7	189	4.1×10^{-2}	1.1
Mo-99		0.6	16.2	0.5	13.5	1.8×10^4	4.8×10^5
N-13	Nitrogen(7)	0.6	16.2	0.5	13.5	5.4×10^7	1.5×10^9
Na-22	Sodium(11)	0.5	13.5	0.5	13.5	2.3×10^2	6.3×10^3
Na-24		0.2	5.41	0.2	5.41	3.2×10^5	8.7×10^6
Nb-92m	Niobium(41)	0.7	18.9	0.7	18.9	5.2×10^3	1.4×10^5
Nb-93m		40	1080	6	162	8.8	2.4×10^2
Nb-94		0.6	16.2	0.6	16.2	6.9×10^{-3}	1.9×10^{-1}
Nb-95		1	27.0	1	27.0	1.5×10^3	3.9×10^4

For mixed fission products, use formula for mixtures or Table A-2

TABLE A-1.—A₁ AND A₂ VALUES FOR RADIONUCLIDES—Continued

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
Nb-97		0.6	16.2	0.5	13.5	9.9×10 ⁵	2.7×10 ⁷
Nd-147	Neodymium(60)	4	108	0.5	13.5	3.0×10 ³	8.1×10 ⁴
Nd-149		0.6	16.2	0.5	13.5	4.5×10 ⁵	1.2×10 ⁷
Ni-59	Nickel(28)	40	1080	40	1080	3.0×10 ⁻³	8.0×10 ⁻²
Ni-63		40	1080	30	811	2.1	5.7×10 ¹
Ni-65		0.3	8.11	0.3	8.11	7.1×10 ⁵	1.9×10 ⁷
Np-235	Neptunium(93)	40	1080	40	1080	5.2×10 ¹	1.4×10 ³
Np-236		7	189	1×10 ⁻³	2.70×10 ⁻²	4.710×10 ⁻⁴	1.3×10 ⁻²
Np-237		2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	2.6×10 ⁻⁵	7.1×10 ⁻⁴
Np-239		6	162	0.5	13.5	8.6×10 ³	2.3×10 ⁵
Os-185	Osmium(76)	1	27.0	1	27.0	2.8×10 ²	7.5×10 ³
Os-191m		40	1080	40	1080	4.6×10 ⁴	1.3×10 ⁶
Os-191		10	270	0.9	24.3	1.6×10 ³	4.4×10 ⁴
Os-193		0.6	16.2	0.5	13.5	2.0×10 ⁴	5.3×10 ⁵
Os-194		0.2	5.41	0.2	5.41	1.1×10 ¹	3.1×10 ²
P-32	Phosphorus(15)	0.3	8.11	0.3	8.11	1.1×10 ⁴	2.9×10 ⁵
P-33		40	1080	0.9	24.3	5.8×10 ³	1.6×10 ⁵
Pa-230	Protactinium(91)	2	54.1	0.1	2.70	1.2×10 ³	3.3×10 ⁴
Pa-231		0.6	16.2	6×10 ⁻⁵	1.62×10 ⁻³	1.7×10 ⁻³	4.7×10 ⁻²
Pa-233		5	135	0.9	24.3	7.7×10 ²	2.1×10 ⁴
Pb-201	Lead(82)	1	27.0	1	27.0	6.2×10 ⁴	1.7×10 ⁶
Pb-202		40	1080	2	54.1	1.2×10 ⁻⁴	3.4×10 ⁻³
Pb-203		3	81.1	3	81.1	1.1×10 ⁴	3.0×10 ⁵
Pb-205		Unlimited	Unlimited	Unlimited	Unlimited	4.5×10 ⁻⁶	1.2×10 ⁻⁴
Pb-210		0.6	16.2	9×10 ⁻³	0.243	2.8	7.6×10 ¹
Pb-212		0.3	8.11	0.3	8.11	5.1×10 ⁴	1.4×10 ⁶
Pd-103	Palladium(46)	40	1080	40	1080	2.8×10 ³	7.5×10 ⁴
Pd-107		Unlimited	Unlimited	Unlimited	Unlimited	1.9×10 ⁻⁵	5.1×10 ⁻⁴
Pd-109		0.6	16.2	0.5	13.5	7.9×10 ⁴	2.1×10 ⁶
Pm-143	Promethium(61)	3	81.1	3	81.1	1.3×10 ²	3.4×10 ³
Pm-144		0.6	16.2	0.6	16.2	9.2×10 ¹	2.5×10 ³
Pm-145		30	811	7	189	5.2	1.4×10 ²
Pm-147		40	1080	0.9	24.3	3.4×10 ¹	9.3×10 ²
Pm-148m		0.5	13.5	0.5	13.5	7.9×10 ²	2.1×10 ⁴
Pm-149		0.6	16.2	0.5	13.5	1.5×10 ⁴	4.0×10 ⁵
Pm-151		3	81.1	0.5	13.5	2.7×10 ⁴	7.3×10 ⁵
Po-208	Polonium(84)	40	1080	2×10 ⁻²	0.541	2.2×10 ¹	5.9×10 ²
Po-209		40	1080	2×10 ⁻²	0.541	6.2×10 ⁻¹	1.7×10 ¹
Po-210		40	1080	2×10 ⁻²	0.541	1.7×10 ²	4.5×10 ³
Pr-142	Praseodymium(59)	0.2	5.41	0.2	5.41	4.3×10 ⁴	1.2×10 ⁶
Pr-143		4	108	0.5	13.5	2.5×10 ³	6.7×10 ⁴
Pt-188	Platinum(78)	0.6	16.2	0.6	16.2	2.5×10 ³	6.8×10 ⁴
Pt-191		3	81.1	3	81.1	8.7×10 ³	2.4×10 ⁵
Pt-193m		40	1080	9	243	5.8×10 ³	1.6×10 ⁵

Pt-193	40	1080	40	1080	1.4	3.7×10 ¹
Pt-195m	10	270	2	54.1	6.2×10 ³	1.7×10 ⁵
Pt-197m	10	270	0.9	24.3	3.7×10 ⁵	1.0×10 ⁷
Pt-197	20	541	0.5	13.5	3.2×10 ⁴	8.7×10 ⁵
Pu-236	7	189	7×10 ⁻⁴	1.89×10 ⁻²	2.0×10 ¹	5.3×10 ²
Pu-237	20	541	20	541	4.5×10 ²	1.2×10 ⁴
Pu-238	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	6.3×10 ⁻¹	1.7×10 ¹
Pu-239	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	2.3×10 ⁻³	6.2×10 ⁻²
Pu-240	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	8.4×10 ⁻³	2.3×10 ⁻¹
Pu-241	40	1080	1×10 ⁻²	0.270	3.8	1.0×10 ²
Pu-242	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	1.5×10 ⁻⁴	3.9×10 ⁻³
Pu-244	0.3	8.11	2×10 ⁻⁴	5.41×10 ⁻³	6.7×10 ⁻⁷	1.8×10 ⁻⁵
Ra-223	0.6	16.2	3×10 ⁻²	0.811	1.9×10 ³	5.1×10 ⁴
Ra-224	0.3	8.11	6×10 ⁻²	1.62	5.9×10 ³	1.6×10 ⁵
Ra-225	0.6	16.2	2×10 ⁻²	0.541	1.5×10 ³	3.9×10 ⁴
Ra-226	0.3	8.11	2×10 ⁻²	0.541	3.7×10 ⁻²	1.0
Ra-228	0.6	16.2	4×10 ⁻²	1.08	1.0×10 ¹	2.7×10 ²
Rb-81	2	54.1	0.9	24.3	3.1×10 ⁵	8.4×10 ⁶
Rb-83	2	54.1	2	54.1	6.8×10 ²	1.8×10 ⁴
Rb-84	1	27.0	0.9	24.3	1.8×10 ³	4.7×10 ⁴
Rb-86	0.3	8.11	0.3	8.11	3.0×10 ³	8.1×10 ⁴
Rb-87	Unlimited	Unlimited	Unlimited	Unlimited	3.2×10 ⁻⁹	8.6×10 ⁻⁸
Rb (natural)	Unlimited	Unlimited	Unlimited	Unlimited	6.7×10 ⁶	1.8×10 ⁸
Re-183	5	135	5	135	3.8×10 ²	1.0×10 ⁴
Re-184m	3	81.1	3	81.1	1.6×10 ²	4.3×10 ³
Re-184	1	27.0	1	27.0	6.9×10 ²	1.9×10 ⁴
Re-186	4	108	0.5	13.5	6.9×10 ³	1.9×10 ⁵
Re-187	Unlimited	Unlimited	Unlimited	Unlimited	1.4×10 ⁻⁹	3.8×10 ⁻⁸
Re-188	0.2	5.41	0.2	5.41	3.6×10 ⁴	9.8×10 ⁵
Re-189	4	108	0.5	13.5	2.5×10 ⁴	6.8×10 ⁵
Re (natural)	Unlimited	Unlimited	Unlimited	Unlimited		2.4×10 ⁻⁸
Rh-99	2	54.1	2	54.1	3.0×10 ³	8.2×10 ⁴
Rh-101	4	108	4	108	4.1×10 ¹	1.1×10 ³
Rh-102m	2	54.1	0.9	24.3	2.3×10 ²	6.2×10 ³
Rh-102	0.5	13.5	0.5	13.5	4.5×10 ¹	1.2×10 ³
Rh-103m	40	1080	40	1080	1.2×10 ⁶	3.3×10 ⁷
Rh-105	10	270	0.9	24.3	3.1×10 ⁴	8.4×10 ⁵
Rn-222	0.2	5.41	4×10 ⁻³	0.108	5.7×10 ³	1.5×10 ⁵
Ru-97	4	108	4	108	1.7×10 ⁴	4.6×10 ⁵
Ru-103	2	54.1	0.9	24.3	1.2×10 ³	3.2×10 ⁴
Ru-105	0.6	16.2	0.5	13.5	2.5×10 ⁵	6.7×10 ⁶
Ru-106	0.2	5.41	0.2	5.41	1.2×10 ²	3.3×10 ³
S-35	40	1080	2	54.1	1.6×10 ³	4.3×10 ⁴
Sb-122	0.3	8.11	0.3	8.11	1.5×10 ⁴	4.0×10 ⁵
Sb-124	0.6	16.2	0.5	13.5	6.5×10 ²	1.7×10 ⁴
Sb-125	2	54.1	0.9	24.3	3.9×10 ¹	1.0×10 ³
Sb-126	0.4	10.8	0.4	10.8	3.1×10 ³	8.4×10 ⁴
Sc-44	0.5	13.5	0.5	13.5	6.7×10 ⁵	1.8×10 ⁷
Sc-46	0.5	13.5	0.5	13.5	1.3×10 ³	3.4×10 ⁴
Sc-47	9	243	0.9	24.3	3.1×10 ⁴	8.3×10 ⁵

TABLE A-1.—A₁ AND A₂ VALUES FOR RADIONUCLIDES—Continued

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
Sc-48		0.3	8.11	0.3	8.11	5.5×10 ⁴	1.5×10 ⁶
Se-75	Selenium(34)	3	81.1	3	81.1	5.4×10 ²	1.5×10 ⁴
Se-79		40	1080	2	54.1	2.6×10 ⁻³	7.0×10 ⁻²
Si-31	Silicon(14)	0.6	16.2	0.5	13.5	1.4×10 ⁶	3.9×10 ⁷
Si-32		40	1080	0.2	5.41	3.9	1.1×10 ²
Sm-145	Samarium(62)	20	541	20	541	9.8×10 ¹	2.6×10 ³
Sm-147		Unlimited	Unlimited	Unlimited	Unlimited	8.5×10 ⁻¹	2.3×10 ⁻⁸
Sm-151		40	1080	4	108	9.7×10 ⁻¹	2.6×10 ¹
Sm-153		4	108	0.5	13.5	1.6×10 ⁴	4.4×10 ⁵
Sn-113	Tin(50)	4	108	4	108	3.7×10 ²	1.0×10 ⁴
Sn-117m		6	162	2	54.1	3.0×10 ³	8.2×10 ⁴
Sn-119m		40	1080	40	1080	1.4×10 ²	3.7×10 ³
Sn-121m		40	1080	0.9	24.3	2.0	5.4×10 ¹
Sn-123		0.6	16.2	0.5	13.5	3.0×10 ²	8.2×10 ³
Sn-125		0.2	5.41	0.2	5.41	4.0×10 ³	1.1×10 ⁵
Sn-126		0.3	8.11	0.3	8.11	1.0×10 ⁻³	2.8×10 ⁻²
Sr-82	Strontium(38)	0.2	5.41	0.2	5.41	2.3×10 ³	6.2×10 ⁴
Sr-85m		5	135	5	135	1.2×10 ⁶	3.3×10 ⁷
Sr-85		2	54.1	2	54.1	8.8×10 ²	2.4×10 ⁴
Sr-87m		3	81.1	3	81.1	4.8×10 ⁵	1.3×10 ⁷
Sr-89		0.6	16.2	0.5	13.5	1.1×10 ³	2.9×10 ⁴
Sr-90		0.2	5.41	0.1	2.70	5.1	1.4×10 ²
Sr-91		0.3	8.11	0.3	8.11	1.3×10 ⁵	3.6×10 ⁶
Sr-92		0.8	21.6	0.5	13.5	4.7×10 ⁵	1.3×10 ⁷
T	Tritium(1)	40	1080	40	1080	3.6×10 ²	9.7×10 ³
Ta-178	Tantalum(73)	1	27.0	1	27.0	4.2×10 ⁶	1.1×10 ⁸
Ta-179		30	811	30	811	4.1×10 ¹	1.1×10 ³
Ta-182		0.8	21.6	0.5	13.5	2.3×10 ²	6.2×10 ³
Tb-157	Terbium(65)	40	1080	10	270	5.6×10 ⁻¹	1.5×10 ¹
Tb-158		1	27.0	0.7	18.9	5.6×10 ⁻¹	1.5×10 ¹
Tb-160		0.9	24.3	0.5	13.5	4.2×10 ²	1.1×10 ⁴
Tc-95m	Technetium(43)	2	54.1	2	54.1	8.3×10 ²	2.2×10 ⁴
Tc-96m		0.4	10.8	0.4	10.8	1.4×10 ⁶	3.8×10 ⁷
Tc-96		0.4	10.8	0.4	10.8	1.2×10 ⁴	3.2×10 ⁵
Tc-97m		40	1080	40	1080	5.6×10 ²	1.5×10 ⁴
Tc-97		Unlimited	Unlimited	Unlimited	Unlimited	5.2×10 ⁻⁵	1.4×10 ⁻³
Tc-98		0.7	18.9	0.7	18.9	3.2×10 ⁻⁵	8.7×10 ⁻⁴
Tc-99m		8	216	8	216	1.9×10 ⁵	5.3×10 ⁶
Tc-99		40	1080	0.9	24.3	6.3×10 ⁻⁴	1.7×10 ⁻²
Te-118	Tellurium(52)	0.2	5.41	0.2	5.41	6.8×10 ³	1.8×10 ⁵
Te-121m		5	135	5	135	2.6×10 ²	7.0×10 ³
Te-121		2	54.1	2	54.1	2.4×10 ³	6.4×10 ⁴
Te-123m		7	189	7	189	3.3×10 ²	8.9×10 ³
Te-125m		30	811	9	243	6.7×10 ²	1.8×10 ⁴

Te-127m	20	541	0.5	13.5	3.5×10 ²	9.4×10 ³
Te-127	20	541	0.5	13.5	9.8×10 ⁴	2.6×10 ⁶
Te-129m	0.6	16.2	0.5	13.5	1.1×10 ³	3.0×10 ⁴
Te-129	0.6	16.2	0.5	13.5	7.7×10 ⁵	2.1×10 ⁷
Te-131m	0.7	18.9	0.5	13.5	3.0×10 ⁴	8.0×10 ⁵
Te-132	0.4	10.8	0.4	10.8	1.1×10 ⁴	3.0×10 ⁵
Th-227	9	243	1×10 ⁻²	0.270	1.1×10 ³	3.1×10 ⁴
Th-228	0.3	8.11	4×10 ⁻⁴	1.08×10 ⁻²	3.0×10 ¹	8.2×10 ²
Th-229	0.3	8.11	3×10 ⁻⁵	8.11×10 ⁻⁴	7.9×10 ⁻³	2.1×10 ⁻¹
Th-230	2	54.1	2×10 ⁻⁴	5.41×10 ⁻³	7.6×10 ⁻⁴	2.1×10 ⁻²
Th-231	40	1080	0.9	24.3	2.0×10 ⁴	5.3×10 ⁵
Th-232	Unlimited	Unlimited	Unlimited	Unlimited	4.0×10 ⁻⁹	1.1×10 ⁻⁷
Th-234	0.2	5.41	0.2	5.41	8.6×10 ²	2.3×10 ⁴
Th (natural)	Unlimited	Unlimited	Unlimited	Unlimited	8.1×10 ⁻⁹	2.2×10 ⁻⁷
Ti-44	0.5	13.5	0.2	5.41	6.4	1.7×10 ²
Ti-200	0.8	21.6	0.8	21.6	2.2×10 ⁴	6.0×10 ⁵
Ti-201	10	270	10	270	7.9×10 ³	2.1×10 ⁵
Ti-202	2	54.1	2	54.1	2.0×10 ³	5.3×10 ⁴
Ti-204	4	108	0.5	13.5	1.7×10 ¹	4.6×10 ²
Tm-167	7	189	7	189	3.1×10 ³	8.5×10 ⁴
Tm-168	0.8	21.6	0.8	21.6	3.1×10 ²	8.3×10 ³
Tm-170	4	108	0.5	13.5	2.2×10 ²	6.0×10 ³
Tm-171	40	1080	10	270	4.0×10 ¹	1.1×10 ³
U-230	40	1080	1×10 ⁻²	0.270	1.0×10 ³	2.7×10 ⁴
U-232	3	81.1	3×10 ⁻⁴	8.11×10 ⁻³	8.3×10 ⁻¹	2.2×10 ¹
U-233	10	270	1×10 ⁻³	2.70×10 ⁻²	3.6×10 ⁻⁴	9.7×10 ⁻³
U-234	10	270	1×10 ⁻³	2.70×10 ⁻²	2.3×10 ⁻⁴	6.2×10 ⁻³
U-235	Unlimited	Unlimited	Unlimited	Unlimited	8.0×10 ⁻⁸	2.2×10 ⁻⁶
U-236	10	270	1×10 ⁻³	2.70×10 ⁻²	2.4×10 ⁻⁶	6.5×10 ⁻⁵
U-238	Unlimited	Unlimited	Unlimited	Unlimited	1.2×10 ⁻⁸	3.4×10 ⁻⁷
U (natural)	Unlimited	Unlimited	Unlimited	Unlimited	2.6×10 ⁻⁸	7.1×10 ⁻⁷
U (enriched 5% or less)	Unlimited	Unlimited	Unlimited	Unlimited		(See Table A-3)
U (enriched more than 5%)	10	270	1×10 ⁻³	2.70×10 ⁻²		(See Table A-3)
U (depleted)	Unlimited	Unlimited	Unlimited	Unlimited		(See Table A-3)
V-48	0.3	8.11	0.3	8.11	6.3×10 ³	1.7×10 ⁵
V-49	40	1080	40	1080	3.0×10 ²	8.1×10 ³
W-178	1	27.0	1	27.0	1.3×10 ³	3.4×10 ⁴
W-181	30	811	30	811	2.2×10 ²	6.0×10 ³
W-185	40	1080	0.9	24.3	3.5×10 ²	9.4×10 ³
W-187	2	54.1	0.5	13.5	2.6×10 ⁴	7.0×10 ⁵
W-188	0.2	5.41	0.2	5.41	3.7×10 ²	1.0×10 ⁴
Xe-122	0.2	5.41	0.2	5.41	4.8×10 ⁴	1.3×10 ⁶
Xe-123	0.2	5.41	0.2	5.41	4.4×10 ⁵	1.2×10 ⁷
Xe-127	4	108	4	108	1.0×10 ³	2.8×10 ⁴
Xe-131m	40	1080	40	1080	3.1×10 ³	8.4×10 ⁴
Xe-133	20	541	20	541	6.9×10 ³	1.9×10 ⁵
Xe-135	4	108	4	108	9.5×10 ⁴	2.6×10 ⁶
Y-87	2	54.1	2	54.1	1.7×10 ⁴	4.5×10 ⁵

TABLE A-1.—A₁ AND A₂ VALUES FOR RADIONUCLIDES—Continued

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
Y-88		0.4	10.8	0.4	10.8	5.2×10 ²	1.4×10 ⁴
Y-90		0.2	5.41	0.2	5.41	2.0×10 ⁴	5.4×10 ⁵
Y-91m		2	54.1	2	54.1	1.5×10 ⁶	4.2×10 ⁷
Y-91		0.3	8.11	0.3	8.11	9.1×10 ²	2.5×10 ⁴
Y-92		0.2	5.41	0.2	5.41	3.6×10 ⁵	9.6×10 ⁶
Y-93		0.2	5.41	0.2	5.41	1.2×10 ⁵	3.3×10 ⁶
Yb-169	Ytterbium(70)	3	81.1	3	81.1	8.9×10 ²	2.4×10 ⁴
Yb-175		30	811	0.9	24.3	6.6×10 ³	1.8×10 ⁵
Zn-65	Zinc(30)	2	54.1	2	54.1	3.0×10 ²	8.2×10 ³
Zn-69m		2	54.1	0.5	13.5	1.2×10 ⁵	3.3×10 ⁶
Zn-69		4	108	0.5	13.5	1.8×10 ⁶	4.9×10 ⁷
Zr-88	Zirconium(40)	3	81.1	3	81.1	6.6×10 ²	1.8×10 ⁴
Zr-93		40	1080	0.2	5.41	9.3×10 ⁻⁵	2.5×10 ⁻³
Zr-95		1	27.0	0.9	24.3	7.9×10 ²	2.1×10 ⁴
Zr-97		0.3	8.11	0.3	8.11	7.1×10 ⁴	1.9×10 ⁶

^aInternational shipments of Einsteinium require multilateral approval of A₁ and A₂ values.

^bInternational shipments of Fermium require multilateral approval of A₁ and A₂ values.

^c20 Ci for Mo99 for domestic use.

TABLE A-2.—GENERAL VALUES FOR A₁ AND A₂

Contents	A ₁	(Ci)	A ₂	
	(TBq)		(TBq)	(Ci)
Only beta- or gamma-emitting nuclides are known to be present	0.2	5	0.02	0.5
Alpha-emitting nuclides are known to be present, or no relevant data are available	0.10	2.70	2x10 ⁻⁵	5.41x10 ⁻⁴

TABLE A-3.—ACTIVITY-MASS RELATIONSHIPS FOR URANIUM

Uranium Enrichment ¹ wt % U-235 present	Specific Activity	
	TBq/g	Ci/g
0.45	1.8x10 ⁻⁸	5.0x10 ⁻⁷
0.72	2.6x10 ⁻⁸	7.1x10 ⁻⁷
1.0	2.8x10 ⁻⁸	7.6x10 ⁻⁷
1.5	3.7x10 ⁻⁸	1.0x10 ⁻⁶
5.0	1.0x10 ⁻⁷	2.7x10 ⁻⁶
10.0	1.8x10 ⁻⁷	4.8x10 ⁻⁶
20.0	3.7x10 ⁻⁷	1.0x10 ⁻⁵
35.0	7.4x10 ⁻⁷	2.0x10 ⁻⁵
50.0	9.3x10 ⁻⁷	2.5x10 ⁻⁵
90.0	2.2x10 ⁻⁶	5.8x10 ⁻⁵
93.0	2.6x10 ⁻⁶	7.0x10 ⁻⁵
95.0	3.4x10 ⁻⁶	9.1x10 ⁻⁵

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

[60 FR 50264, Sept. 28, 1995, as amended at 61 FR 28724, June 6, 1996]

PART 72—LICENSING REQUIREMENTS FOR THE INDEPENDENT STORAGE OF SPENT NUCLEAR FUEL, HIGH-LEVEL RADIOACTIVE WASTE, AND REACTOR-RELATED GREATER THAN CLASS C WASTE

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