(c) Each complete unit must be individually and tightly packed to prevent movement in wooden boxes (4C1 or 4C2), plywood boxes (4D), reconstituted wood boxes (4F), fiberboard boxes (4G), or plastic boxes, (4H1 and 4H2) of Packing Group II performance level, or in the original manufacturer's transit box.

§173.336 Nitrogen dioxide, liquefied, or dinitrogen tetroxide, liquefied.
Nitrogen dioxide, liquefied, or dinitrogen tetroxide, liquefied, must be packaged in specification cylinders as follows:

(a) As prescribed in §173.192, or

(b) Specification 3A480, 3AA480, 3AL1800, or 3E1800 metal cylinders, with valves removed, are authorized. Each valve opening must be closed by means of a solid metal plug with tapered thread properly luted to prevent leakages; valve protection cap must be used and be at least 4.76 mm (0.187 inches) thick gas-tight, with 4.76 mm (0.187 inches) faced seat for gasket and with United States standard form thread. Transportation in 3AL cylinders is authorized only by highway or rail. Each cylinder must be cleaned in compliance with the requirements of Federal Specification RR-C-901c, paragraphs 3.7.2 and 3.8.2. Cleaning agents equivalent to those specified in RR-C-901b may be used; however, any cleaning agent must not be capable of reacting with oxygen. One cylinder selected at random from a group of 200 or less cleaned at the same time must be tested for oil contamination in accordance with Specification RR-C-901b paragraph 4.4.2.3 and meet the standard of cleanliness specified therein.

§173.337 Nitric oxide.
Nitric oxide must be packed in Specification 3A1800, 3AA1800, 3E1800, or 3AL1800 cylinders charged to a pressure of not more than 5,170 kPa (750 psi) at 21°C (70°F). Cylinders must be equipped with a valve of stainless steel and valve seat of material which will not be deteriorated by contact with nitric oxide or nitrogen dioxide. Cylinders or valves may not be equipped with pressure relief devices of any type. Valve outlets must be sealed by a solid threaded cap or plug and an inert gasketing material. In addition —

(a) Specification 3E1800 cylinders must be overpacked in strong wooden boxes of such design as to protect valves from injury or accidental functioning under conditions incident to transportation. Each overpack must conform to §173.25.

(b) Specification 3A, 3AA, and 3AL cylinders must have their valves protected by metal caps or other equally protective guards securely attached to the cylinders and be of sufficient strength to protect the valves from injury during transit, or by overpacking in strong wooden boxes of such design as to protect valves from injury or accidental functioning under conditions incident to transportation. Each overpack must conform to §173.25. Transportation in 3AL cylinders is authorized only by highway or rail.

(c) Each cylinder must be cleaned in compliance with the requirements of Federal Specification RR-C-901C paragraphs 3.7.2 and 3.8.2. Cleaning agents equivalent to those specified in RR-C-901C may be used; however, any cleaning agent must not be capable of reacting with oxygen. One cylinder selected at random from a group of 200 or less cleaned at the same time must be tested for oil contamination in accordance with Specification RR-C-901C paragraph 4.4.2.3 and meet the standard of cleanliness specified therein.

§173.338 Tungsten hexafluoride.
Tungsten hexafluoride must be packed in specification 3A, 3AA, 3BN, or 3E (§§178.36, 178.37, 178.39, 178.42 of this subchapter) cylinders. Cylinders must be equipped with a valve protection cap or be packed in a strong outside container complying with the provisions of §173.40. Outlets of any valves must be capped or plugged. As an alternative, the cylinder opening may be closed by the use of a metal plug. Specification 3E cylinders must be shipped in an overpack that complies with the provisions of §173.40.

§173.340 Tear gas devices.
(a) Packagings for tear gas devices must be approved prior to initial transportation by the Associate Administrator for Hazardous Materials Safety.

(b) Tear gas devices may not be assembled with, or packed in the same packaging with, mechanically- or manually-operated firing, igniting, bursting, or other functioning elements unless of a type and design which has been approved by the Associate Administrator for Hazardous Materials Safety.

(c) Tear gas grenades, tear gas candles, and similar devices must be packaged in one of the following packagings conforming to the requirements of Part 178 of this subchapter at the Packing Group II performance level:

(1) In UN 4C1, 4C2, 4D, or 4F metal-strapped wooden boxes. Functioning elements not assembled in grenades or devices must be in a separate compartment of these boxes, or in inner or separate outer boxes, UN 4C1, 4C2, 4D, or 4F, and must be so packed and cushioned that they may not come in contact with each other or with the walls of the box during transportation. Not more than 50 tear gas devices and 50 functioning elements must be packed in one box, and the gross weight of the outer box may not exceed 35 kg (77 pounds).

(2) In a UN 1A2 metal drum. Functioning elements must be packed in a separate inner packaging or compartment. Not more than 24 tear gas devices and 24 functioning elements must be packed in one outer drum, and the gross weight of the drum may not exceed 35 kg (77 pounds).

(3) In a UN 4G fiberboard box with inside tear gas devices meeting Specifications 2P or 2Q. Each inside packaging must be placed in fiberboard tubes fitted with metal ends or a fiber box with suitable padding. Not more than 30 inner packagings must be packed in one outer box, and the gross weight of the outer box may not exceed 16 kg (35 pounds).

(4) In other packagings of a type or design which has been approved by the Associate Administrator for Hazardous Materials Safety.

(d) Tear gas devices may be shipped completely assembled when offered by or consigned to the U.S. Department of Defense, provided the functioning elements are so packed that they cannot accidentally function. Outer packagings must be UN 4C1, 4C2, 4D, or 4F metal-strapped wooden boxes.

Subpart H [Reserved]

Subpart I — Class 7 (Radioactive) Materials

§173.401 Scope.
(a) This subpart sets forth requirements for the packaging and transportation of Class 7 (radioactive) materials by offerors and carriers subject to this subchapter. The requirements prescribed in this subpart are in addition to, not in place of, other requirements set forth in this subchapter for Class 7 (radioactive) materials and those of the Nuclear Regulatory Commission in 10 CFR Part 71.

(b) This subpart does not apply to:

(1) Class 7 (radioactive) materials produced, used, transported, or stored within an establishment other than during the course of transportation, including storage in transportation.

(2) Class 7 (radioactive) materials contained in a medical device, such as a heart pacemaker, which is implanted in a human being or live animal.

(3) Class 7 (radioactive) materials that have been injected into, ingested by, or are otherwise placed into, and are still in, human beings or live animals.

§173.403 Definitions.
For purposes of this subpart —

A_1 means the maximum activity of special form Class 7 (radioactive) material permitted in a Type A package.

A_2 means the maximum activity of Class 7 (radioactive) material, other than special form, LSA or SCO, permitted in a Type A package. These values are either listed in §173.435 or derived in accordance with the procedure prescribed in §173.433.

Class 7 (radioactive) material. See the definition of *Radioactive material* in this section.

Closed transport vehicle means a transport vehicle or conveyance equipped with a securely attached exterior enclosure that during normal transportation restricts the access of unauthorized persons to the cargo space containing the Class 7 (radioactive) materials. The enclosure may be either temporary or permanent, and in the case of packaged materials may be of the ''see-through'' type, and must limit access from top, sides, and bottom.

Containment system means the assembly of components of the packaging intended to retain the radioactive contents during transportation.

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.

Design means the description of a special form Class 7 (radioactive) material, a package, packaging, or LSA-III, that enables those items to be fully identified. The description may include specifications, engineering drawings, reports showing compliance with regulatory requirements, and other relevant documentation.

Exclusive use (also referred to in other regulations as ''sole use'' or ''full load'') means 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. The definition does not apply to unirradiated natural uranium and depleted uranium, and natural uranium or depleted uranium that has been irradiated in a thermal reactor. Certain additional exceptions are provided in §173.453.

Fissile material, controlled shipment means any shipment that contains one or more packages that have been assigned, in accordance with §173.457, nuclear criticality control transport indices greater than 10.

Freight container means a reusable container having a volume of 1.81 cubic meters (64 cubic feet) or more, designed and constructed to permit its being lifted with its contents intact and intended primarily for containment of packages in unit form during transportation. A ''small freight container'' is one which has either one outer dimension less than 1.5 meters (4.9 feet) or an internal volume of not more than 3.0 cubic meters (106 cubic feet). All other freight containers are designated as ''large freight containers.''

Highway route controlled quantity means a quantity within a single package which exceeds:

(1) 3,000 times the A_1 value of the radionuclides as specified in §173.435 for special form Class 7 (radioactive) material;

(2) 3,000 times the A_2 value of the radionuclides as specified in §173.435 for normal form Class 7 (radioactive) material; or

(3) 1,000 TBq (27,000 Ci), whichever is least.

Limited quantity of Class 7 (radioactive) material means a quantity of Class 7 (radioactive) material not exceeding the materials package limits specified in §173.425 and conforming with requirements specified in §173.421.

Low Specific Activity (LSA) material means Class 7 (radioactive) material with limited specific activity which 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) Class 7 (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 Class 7 (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 Class 7 (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) that meet the requirements of §173.468 and which:

(i) The Class 7 (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 Class 7 (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 Class 7 (radioactive) material per package by leaching when placed in water for seven days would not exceed 0.1 A_2; and

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

Low toxicity alpha emitters are:

(1) Natural uranium, depleted uranium, and natural thorium;

(2) Ores, concentrates or tailings containing uranium-235, uranium- 238, thorium-232, thorium-228 and thorium-230; or

(3) Alpha emitters with a half-life of less than 10 days. Maximum normal operating pressure means the maximum gauge pressure that would develop in a receptacle in a period of one year, in the absence of venting or cooling, under the heat conditions specified in 10 CFR 71.71(c)(1)

Multilateral approval means approval of a package or shipment by the relevant competent authority of the country of origin and of each country through or into which the package or shipment is to be transported. This definition does not include approval from a country over which Class 7 (radioactive) materials are carried in aircraft, if there is no scheduled stop in that country.

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

Non-fixed radioactive contamination means radioactive contamination that can be readily removed from a surface by wiping with an absorbent material. Non-fixed (removable) radioactive contamination is not significant if it does not exceed the limits specified in §173.443.

Normal form Class 7 (radioactive) material means Class 7 (radioactive) material which has not been demonstrated to qualify as ''special form Class 7 (radioactive) material.''

Package means, for Class 7 (radioactive) materials, the packaging together with its radioactive contents as presented for transport.

(1) ''Excepted package'' means a packaging together with its excepted Class 7 (radioactive) materials as specified in §§173.421-173.426 and 173.428.

(2) ''Type A package'' means a packaging that, together with its radioactive contents limited to A_1 or A_2 as appropriate, meets the requirements of §§173.410 and 173.412 and is designed to retain the integrity of containment and shielding required by this part under normal conditions of transport as demonstrated by the tests set forth in §173.465 or §173.466, as appropriate. A Type A package does not require Competent Authority Approval.

(3) ''Type B package'' means a Type B packaging that, together with its radioactive contents, is designed to retain the integrity of containment and shielding required by this part when subjected to the normal conditions of transport and hypothetical accident test conditions set forth in 10 CFR Part 71.

(i) ''Type B(U) package'' means a Type B packaging that, together with its radioactive contents, for international shipments requires unilateral approval only of the package design and of any stowage provisions that may be necessary for heat dissipation.

(ii) ''Type B(M) package'' means a Type B packaging, together with its radioactive contents, that for international shipments requires multilateral approval of the package design, and may require approval of the conditions of shipment. Type B(M) packages are those Type B package designs which have a maximum normal operating pressure of more than 700 kilopascals per square centimeter (100 pounds per square inch) gauge or a relief device which would allow the release of Class 7 (radioactive) material to the environment under the hypothetical accident conditions specified in 10 CFR Part 71.

(4) ''Industrial package'' means a packaging that, together with its low specific activity (LSA) material or surface contaminated object (SCO) contents, meets the requirements of §§173.410 and 173.411. Industrial packages are categorized in §173.411 as either:

(i) ''Industrial package Type 1 (IP-1)'';

(ii) ''Industrial package Type 2 (IP-2)''; or

(iii) ''Industrial package Type 3 (IP-3)''.

Packaging means, for Class 7 (radioactive) materials, the assembly of components necessary to ensure compliance with the packaging requirements of this subpart. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, service equipment for filling, emptying, venting and pressure relief, and devices for cooling or absorbing mechanical shocks. The conveyance, tie-down system, and auxiliary equipment may sometimes be designated as part of the packaging.

Radiation level means the radiation dose-equivalent rate expressed in millisievert(s) per hour or mSv/h (millirem(s) per hour or mrem/h). Neutron flux densities may be converted into radiation levels according to Table 1:

Table 1 — Neutron Fluence Rates to be Regarded as Equivalent to a Radiation Level of 0.01 mSv/h (1 mrem/h)[1]

Energy of neutron	Flux density equivalent to 0.01 mSv/h (1 mrem/h) neutrons per square centimeter per second ($n/cm^2/s$)
Thermal (2.510E-8)MeV	272.0
1 keV	272.0
10 keV	281.0
100 keV	47.0
500 keV	11.0
1 MeV	7.5
5 MeV	6.4
10 MeV	6.7

[1] Flux densities equivalent for energies between those listed in this table may be obtained by linear interpolation.

Radioactive contents means a Class 7 (radioactive) material, together with any contaminated liquids or gases within the package.

Radioactive instrument and article means any manufactured instrument and article such as an instrument, clock, electronic tube or apparatus, or similar instrument and article having Class 7 (radioactive) material in gaseous or non-dispersible solid form as a component part.

Radioactive material means any material having a specific activity greater than 70 Bq per gram (0.002 microcurie per gram) (see definition of ''specific activity'').

Special form Class 7 (radioactive) material means Class 7 (radioactive) material which 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 millimeters (0.2 inch); and

(3) It satisfies the test requirements of §173.469. Special form encapsulations designed in accordance with the requirements of §173.389(g) in effect on June 30, 1983 (see 49 CFR Part 173, revised as of October 1, 1982), and constructed prior to July 1, 1985 and special form encapsulations designed in accordance with the requirements of §173.403 in effect on March 31, 1996 (see 49 CFR Part 173, revised as of October 1, 1995), and constructed prior to April 1, 1997, may continue to be used. Any other special form encapsulation must meet the requirements of this paragraph.

Specific activity of a radionuclide means the activity 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 activity per unit mass of the material.

Surface Contaminated Object (SCO) means a solid object which is not itself radioactive but which has Class 7 (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 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 4 Bq/cm^2 (10^{-4} microcurie/cm^2) for beta and gamma and low toxicity alpha emitters, or 0.4 Bq/cm^2 (10^{-5} microcurie/cm^2) for 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 4×10^4 Bq/cm^2 (1.0 microcurie/ cm^2) for beta and gamma and low toxicity alpha emitters, or 4×10^3 Bq/cm^2 (0.1 microcurie/cm^2) 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 4×10^4 Bq/ cm^2 (1 microcurie/cm^2) for beta and gamma and low toxicity alpha emitters, or 4×10^3 Bq/cm^2 (0.1 microcurie/ cm^2) 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/ cm^2) for beta and gamma and low toxicity alpha emitters or 40 Bq/ cm^2 (10^{-3} microcurie/cm^2) 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 8×10^5 Bq/cm^2 (20 microcurie/ cm^2) for beta and gamma and low toxicity alpha emitters, or 8×10^4 Bq/cm^2 (2 microcuries/cm^2) 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 8×10^5 Bq/ cm^2 (20 microcuries/cm^2) for beta and gamma and low toxicity alpha emitters, or 8×10^4 Bq/cm^2 (2 microcuries/ cm^2) for all other alpha emitters.

Transport index (TI) 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 nonfissile material packages, the number determined by multiplying the maximum radiation level in milliSievert(s) per hour at one meter (3.3 feet) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at one meter (3.3 feet)); or

(2) For fissile material packages, the number determined by multiplying the maximum radiation level in milliSievert per hour at one meter (3.3 feet) from any external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at one meter (3.3 feet)) or, for criticality control purposes, the number obtained by dividing 50 by the allowable number of packages which may be transported together, whichever number is larger.

Type A quantity means a quantity of Class 7 (radioactive) material, the aggregate radioactivity which does not exceed A_1 for special form Class 7 (radioactive) material or A_2 for normal form Class 7 (radioactive) material, where A_1 and A_2 values are given in §173.435 or are determined in accordance with §173.433.

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

Unilateral approval means approval of a package solely by the competent authority of the country of origin.

Unirradiated thorium means thorium containing not more than 10^{-7} grams uranium-233 per gram of thorium-232.

Unirradiated uranium means uranium containing not more than 10^{-6} grams plutonium per gram of uranium-235 and a fission product activity of not more than 9 MBq (0.24 millicuries) of fission products per gram of uranium-235.

Uranium—natural, depleted or enriched means the following:

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

§173.410 General design requirements.

In addition to the requirements of subparts A and B of this part, each package used for the shipment of Class 7 (radioactive) materials must be designed so that —

(a) The package can be easily handled and properly secured in or on a conveyance during transport.

(b) Each lifting attachment that is a structural part of the 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 attachment 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 which 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.

(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.

(d) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.

(e) Each feature that is added to the package will not reduce the safety of the package.

(f) The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see §§173.24, 173.24a, and 173.24b).

(g) The materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.

(h) All valves through which the package contents could escape will be protected against unauthorized operation;

(i) For transport by air —

(1) The temperature of the accessible surfaces of the package will not exceed 50°C (122°F) at an ambient temperature of 38°C (100°F) with no account taken for insulation;

(2) The integrity of containment will not be impaired if the package is exposed to ambient temperatures ranging from -40°C (-40°F) to +55°C (131°F); and

(3) Packages containing liquid contents will be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than 95 kPa (13.8 lb./in^2).

§173.411 Industrial packagings.

(a) *General.* Each industrial packaging must comply with the requirements of this section which specifies packaging tests, and record retention applicable to Industrial Packaging Type 1 (IP-1), Industrial Packaging Type 2 (IP-2), and Industrial Packaging Type 3 (IP-3).

(b) *Industrial packaging certification and tests.*

(1) Each IP-1 must meet the general design requirements prescribed in §173.410.

(2) Each IP-2 must meet the general design requirements prescribed in §173.410 and when subjected to the tests specified in §173.465 (c) and (d) or

evaluated against these tests by any of the methods authorized by §173.461(a), must prevent:

(i) Loss or dispersal of the radioactive contents; and

(ii) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.

(3) Each IP-3 packaging must meet the requirements for an IP-1 and an IP-2, and must meet the requirements specified in §173.412(a) through §173.412(j).

(4) Each specification IM 101 or IM 102 portable tank (§§178.270, 178.271, 178.272 of this subchapter) that is certified as meeting the requirements for an IP-2 or IP-3 must:

(i) Satisfy the requirements for IP-2 or IP-3, respectively;

(ii) Be capable of withstanding a test pressure of 265 kPa (37.1 pounds per square inch) gauge;

(iii) Be designed so that any added shielding is capable of withstanding the static and dynamic stresses resulting from normal handling and normal conditions of transport; and

(iv) Be designed so that loss of shielding will not result in a significant increase in the radiation levels recorded at the external surfaces.

(5) Each freight container that is certified as meeting the requirements of IP-2 or IP-3, must —

(i) Satisfy the requirements for IP-2 or IP-3, respectively;

(ii) Be designed to conform to the requirements of ISO 1496-3-1995(E), ''Series 1 Freight Containers—Specifications and Testing—Part 3: Tank Containers for Liquids, Gases and Pressurized Dry Bulk'';

(iii) Be designed so that loss of shielding will not result in a significant increase in the radiation levels recorded at the external surfaces if they are subjected to the tests specified in ISO 1496/1-1995(E); and

(iv) For international transportation, have a safety approval plate in conformance with 49 CFR 451.21 through 451.25.

(c) Except for IP-1 packagings, each offeror of an industrial package must maintain on file for at least one year after the latest shipment, and shall provide to the Associate Administrator for Hazardous Materials Safety on request, complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with that specification.

§173.412 Additional design requirements for Type A packages.

In addition to meeting the general design requirements prescribed in §173.410, each Type A packaging must be designed so that —

(a) The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may be sealed.

(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).

(c) Containment and shielding is maintained during transportation and storage in a temperature range of -40°C (-40°F) to 70°C (158°F). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.

(d) The packaging must include a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form Class 7 (radioactive) material, as demonstrated in accordance with §173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.

(e) For each component of the containment system account is taken, where applicable, of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis.

(f) The containment system will retain its radioactive contents under the reduction of ambient pressure to 25 kPa (3.6 pounds per square inch).

(g) Each valve, other than a pressure relief device, is provided with an enclosure to retain any leakage.

(h) Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield.

(i) Failure of any tie-down attachment that is a structural part of the packaging, under both normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.

(j) When evaluated against the performance requirements of this section and the tests specified in §173.465 or using any of the methods authorized by §173.461(a), the packaging will prevent —

(1) Loss or dispersal of the radioactive contents; and

(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.

(k) Each packaging designed for liquids will —

(1) Be designed to provide for ullage to accommodate variations in temperature of the contents, dynamic effects and filling dynamics;

(2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a); and

(3) Either —

(i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or

(ii) Have a containment system composed of primary inner and secondary outer containment components designed to assure retention of the liquid contents within the secondary outer component in the event that the primary inner component leaks.

(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000Ci) or noble gases not exceeding the A_2 value appropriate for the noble gas, will be able to prevent loss or dispersal of contents when the package is subjected to the tests prescribed in §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a).

§173.413 Requirements for Type B packages.

Except as provided in §173.416, each Type B(U) or Type B(M) package must be designed and constructed to meet the applicable requirements specified in 10 CFR Part 71.

§173.415 Authorized Type A packages.

The following packages are authorized for shipment if they do not contain quantities exceeding A_1 or A_2 as appropriate:

(a) DOT Specification 7A (§178.350 of this subchapter) Type A general packaging. Each offeror of a Specification 7A package must maintain on file for at least one year after the latest shipment, and shall provide to DOT on request, complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with that specification. Use of Specification 7A packagings designed in accordance with the requirements of §178.350 of this subchapter in effect on June 30, 1983 (see 49 CFR Part 178 revised as of October 1, 1982), is not authorized after April 1, 1997.

(b) Any other Type A packaging that also meets the applicable standards for fissile materials in 10 CFR Part 71 and is used in accordance with §173.471.

(c) Any Type B, B(U) or B(M) packaging authorized pursuant to §173.416.

(d) Any foreign-made packaging that meets the standards in IAEA ''Safety Series No. 6'' and bears the marking ''Type A'' and was used for the import of Class 7 (radioactive) materials. Such packagings may be subsequently used for domestic and export shipments of Class 7 (radioactive) materials provided the offeror obtains the applicable documentation of tests and engineering evaluations and maintains the documentation on file in accordance with paragraph (a) of this section. These packagings must conform with requirements of the country of origin (as indicated by the packaging marking) and the IAEA regulations applicable to Type A packagings.

§173.416 Authorized Type B packages.

Each of the following packages is authorized for shipment of quantities exceeding A_1 or A_2, as appropriate:

(a) Any Type B, Type B(U) or Type B(M) packaging that meets the applicable requirements of 10 CFR Part 71 and that has been approved by the U.S. Nuclear Regulatory Commission may be shipped pursuant to §173.471.

(b) Any Type B, B(U) or B(M) packaging that meets the applicable requirements of the regulations of the International Atomic Energy Agency (IAEA) in its

''Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6'' and for which the foreign competent authority certificate has been revalidated by DOT pursuant to §173.473. These packagings are authorized only for export and import shipments.

(c) DOT Specification 6M (§178.354 of this subchapter) metal packaging, only for solid or gaseous Class 7 (radioactive) materials that will not undergo pressure-generating decomposition at temperatures up to 121°C (250°F) and that do not generate more than 10 watts of radioactive decay heat.

(d) For contents in other than special form; DOT Specification 20WC (§178.362 of this subchapter), wooden protective jacket, when used with a single, snug-fitting inner DOT Specification 2R (§178.360 of this subchapter). For liquid contents, the inner packaging must conform to §173.412(j) and (k).

(e) For contents in special form only; DOT Specification 20WC (§178.362 of this subchapter), wooden protective jacket, with a single snug-fitting inner Type A packaging that has a metal outer wall and conforms to §178.350 of this subchapter. Radioactive decay heat may not exceed 100 watts.

(f) For contents in special form only; DOT Specification 21WC (§178.364 of this subchapter), wooden protective overpack, with a single inner DOT Specification 2R (§178.360 of this subchapter). Contents must be loaded within the inner packaging in such a manner as to prevent loose movement during transportation. The inner packaging must be securely positioned and centered within the overpack so that there will be no significant displacement of the inner packaging if subjected to the 9 meter (30 feet) drop test described in 10 CFR part 71.

§173.417 Authorized fissile materials packages.

(a) Except as provided in §173.453, fissile materials containing not more than A_1 or A_2 as appropriate, must be packaged in one of the following packagings:

(1) DOT Specification 6L (§178.352 of this subchapter), metal packaging, for materials prescribed in paragraph (b)(1) of this section.

(2) DOT Specification 6M (§178.354 of this subchapter), metal packaging, for materials prescribed in paragraph (b)(2) of this section.

(3) Any packaging listed in §173.415, limited to the Class 7 (radioactive) materials specified in 10 CFR part 71, subpart C.

(4) Any other Type A or Type B, Type B(U), or Type B(M) packaging for fissile Class 7 (radioactive) materials that also meets the applicable standards for fissile materials in 10 CFR part 71.

(5) Any other Type A or Type B, Type B(U), or Type B(M) packaging that also meets the applicable requirements for fissile material packaging in Section V of the International Atomic Energy Agency ''Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6,'' and for which the foreign competent authority certificate has been revalidated by the U.S. Competent Authority, in accordance with §173.473. These packages are authorized only for export and import shipments.

(6) A 55-gallon 1A2 steel drum, meeting the applicable packaging testing requirements of subpart M of Part 178 of this subchapter at the packing group I performance level, subject to the following conditions:

(i) The quantity may not exceed 350 grams of uranium-235 in any non-pyrophoric form, enriched to any degree in the uranium-235 isotope;

(ii) Each drum must have a minimum 18 gauge body and bottom head and 16 gauge removable top head with one or more corrugations in the cover near the periphery;

(iii) Closure must conform to §178.352 of this subchapter;

(iv) At least four equally spaced 12 millimeter (0.5 inch) diameter vent holes must be provided on the sides of the drum near the top, each covered with weatherproof tape; or equivalent device;

(v) Appropriate primary, inner containment of the contents and sufficient packaging material, such as plastic or metal jars or cans, must be provided such that Specification 7A (§178.350 of this subchapter) provisions are satisfied by the inner packaging;

(vi) Each inner container must be capable of venting if subjected to the thermal test described in 10 CFR part 71;

(vii) Liquid contents must be packaged in accordance with §173.412 (j) and (k); and

(viii) The maximum weight of contents, including internal packaging, may not exceed 91 kilograms (200 pounds) with fissile material content limited as shown in Table 2:

Table 2—Fissile Material Content and Transport Index for UN1A2 Package

Maximum quantity and minimum transport index		Maximum number of packages transported as a fissile material controlled shipment
U-235 per package (grams)	Minimum transport index per package	
350	1.8	72
300	1.0	129
250	0.5	256
200	0.3	500
150	0.1	500
100	0.1	500
50	([1])	([2])

[1] Transport index is limited by the external radiation levels.
[2] Maximum number is limited by the total transport index.

(7) Any metal cylinder that meets the requirements of §173.415 and §178.350 of this subchapter for Specification 7A Type A packaging may be used for the transport of residual ''heels'' of enriched solid uranium hexafluoride without a protective overpack in accordance with Table 3, as follows:

Table 3 — Allowable Content of Uranium Hexafluoride (UF_6) "Heels" in a Specification 7A Cylinder

Maximum cylinder diameter		Cylinder volume		Maximum Uranium-235 enrichment (weight percent)	Maximum "heel" weight per cylinder			
					UF_6		Uranium-235	
Centimeters	Inches	Liters	Cubic Feet		kg	(lb)	kg	(lb)
12.7	5	8.8	0.311	100.0	0.045	0.1	0.031	0.07
20.3	8	39.0	1.359	12.5	0.227	0.5	0.019	0.04
30.5	12	68.0	2.410	5.0	0.454	1.0	0.015	0.03
76.0	30	725.0	25.64	5.0	11.3	25.0	0.383	0.84
122.0	48	3,084.0	[1]108.9	4.5	22.7	50.0	0.690	1.52
122.0	48	4,041.0	[2]142.7	4.5	22.7	50.0	0.690	1.52

[1] 10 ton.
[2] 14 ton.

(8) DOT Specification 20PF-1, 20PF-2, or 20PF-3 (§178.356 of this subchapter), or Specification 21PF-1A, 21PF-1B, or 21PF-2 (§178.358 of this subchapter) phenolic-foam insulated overpack with snug fitting inner metal cylinders, meeting all requirements of §§173.24, 173.410, 173.412, and 173.420 and the following:

(i) Handling procedures and packaging criteria must be in accordance with DOE Report ORO-651 or ANSI N14.1.

(ii) Quantities of uranium hexafluoride are authorized as shown in Table 6 of this section, with each package assigned a minimum transport index as also shown.

(b) Fissile Class 7 (radioactive) materials with radioactive content exceeding A_1 or A_2 must be packaged in one of the following packagings:

(1) DOT Specification 6L (§178.352 of this subchapter), metal packaging. These packages may contain only uranium-235, plutonium-239, or plutonium-241, as metal, oxide, or compounds that do not decompose at temperatures up to 149°C (300°F). Radioactive decay heat output may not exceed 5 watts. Class 7 (radioactive) materials in normal form must be packaged in one or more tightly sealed metal or polyethylene bottles within a DOT Specification 2R (§178.360 of this subchapter) containment vessel. Authorized contents are limited in accordance with Table 4, as follows:

Table 4 — Authorized Contents in Kilograms (kg) and Conditions for Specification 6L Packages

Uranium-235		Plutonium (Plutonium solutions are not authorized)		Minimum fissile transport index	Maximum number of packages transported as a fissile material control shipment
H/X≤3[1]	3H/X≤10	H/X≤10	10≤H/X≤20		
14	[2]3.6	—	—	1.3	80
—	—	2.5	2.4	1.8	50

[1] H/X is the ratio of hydrogen to fissile atoms in the inner containment with all sources of hydrogen in the containment considered.
[2] Volume not to exceed 3.6 liters.

(2) DOT Specification 6M (§178.354 of this subchapter), metal packaging. These packages must contain only solid Class 7 (radioactive) materials that will not decompose at temperatures up to 121 °C (250°F). Radioactive decay heat output may not exceed 10 watts. Class 7 (radioactive) materials in other than special form must be packaged in one or more tightly sealed metal cans or polyethylene bottles within a DOT Specification 2R (§178.360 of this subchapter) containment vessel.

(i) For fissile material with a criticality TI equal to 0.0, packages are limited to the following amounts of fissile Class 7 (radioactive) materials: 1.6 kilograms of uranium-235; 0.9 kilograms of plutonium (except that due to the 10-watt thermal decay heat limitation, the limit for plutonium-238 is 0.02 kilograms); and 0.5 kilograms of uranium-233. The maximum ratio of hydrogen to fissile material may not exceed three, including all of the sources of hydrogen within the DOT Specification 2R containment vessel.

(ii) Maximum quantities of fissile material and other restrictions for materials with a criticality TI of greater than 0.0 are given in Table 5. The minimum transport index to be assigned per package and, for fissile material, controlled shipments, the allowable number of similar packages per conveyance and per transport vehicle are shown in Table 5. Where a maximum ratio of hydrogen to fissile material is specified in Table 5, only the hydrogen interspersed with the fissile material must be considered. For a uranium-233 shipment, the maximum inside diameter of the inner containment vessel may not exceed 12.1 centimeters (4.75 inches). Where necessary, a tight-fitting steel insert must be used to reduce a larger diameter inner containment vessel specified in §178.354 of this subchapter to the 12.1 centimeter (4.75 inch) limit. Table 5 is as follows:

Table 5—Authorized Contents For Specification 6M Packages[1]

Uranium-233[5]			Uranium-235[4, 7]			Plutonium[2, 3, 4]			Minimum transport index	Maximum number of packages transported as a fissile material control shipment
Metal or alloy	Compounds		Metal or alloy	Compounds		Metal or alloy	Compounds			
H/X = 0[8]	H/X = 0	H/X ≤ 3	H/X = 0	H/X = 0	H/X ≤ 3	H/X = 0	H/X = 0	H/X ≤ 3		
0.5	0.5	0.5	1.6	1.6	1.6	[9]0.9	[9]0.9	[9]0.9	0	NA
3.6	4.4	2.9	7.2	7.6	5.3	3.1	4.1	3.4	0.1	1, 250
[6]4.2	5.2	3.5	8.7	9.6	6.4	3.4	4.5	4.1	0.2	625
[6]5.2	6.8	4.5	11.2	13.9	8.3	4.2		4.5	0.5	250
			13.5	16.0	10.1	4.5			1.0	125
				26.0	16.1				5.0	25
				32.0	19.5				10.0	12

[1] Quantity in kilograms.
[2] Minimum percentage of plutonium-240 is 5 weight percent.
[3] 4.5 kilogram limitation of plutonium due to 10 watt decay heat limitation.
[4] For a mixture of uranium-235 and plutonium an equal amount of uranium-235 may be substituted for any portion of plutonium authorized.
[5] Maximum inside diameter of Specification 2R containment vessel not to exceed 12.1 centimeters (4.75 inches) (see par. (b)(2)(ii) of this section.
[6] Granulated or powdered metal with any particle less than 6.4 millimeters (0.25 inch) in the smallest dimension is not authorized.
[7] Maximum permitted uranium-235 enrichment is 93.5 percent.
[8] H/X is the ratio of hydrogen to fissile atoms in the inner containment.
[9] For P-238, the limit is 0.02kg because of the 10 watt thermal decay limitation.

(3) Type B, or Type B(U), or B(M) packaging that meets the standards for packaging of fissile materials in 10 CFR part 71, and is approved by the U.S. Nuclear Regulatory Commission and used in accordance with §173.471.

(4) Type B, B(U), or B(M) packaging that meets the applicable requirements for fissile Class 7 (radioactive) materials in Section V of the IAEA ''Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6'' and for which the foreign competent authority certificate has been revalidated by the U.S. Competent Authority in accordance with §173.473. These packagings are authorized only for import and export shipments.

(5) DOT Specifications 20PF-1, 20PF-2, or 20PF-3 (§178.356 of this subchapter), or DOT Specifications 21PF-1A or 21PF-1B (§178.358 of this subchapter) phenolic-foam insulated overpack with snug fitting inner metal cylinders, meeting all requirements of §§173.24, 173.410, and 173.412, and the following:

(i) Handling procedures and packaging criteria must be in accordance with DOE Report ORO-651 or ANSI N14.1; and

(ii) Quantities of uranium hexafluoride are authorized as shown in Table 6, with each package assigned a minimum transport index as also shown:

(see next page for table)

Table 6—Authorized Quantities of Uranium Hexafluoride

Protective overpack specification number	Maximum inner cylinder diameter		Maximum weight of UF^6 contents		Maximum U-235 enrichment (weight/percent)	Minimum transport index
	Centimeter	Inches	Kilograms	Pounds		
20PF-1	12.7	5	25	55	100.0	0.1
20PF-2	20.3	8	116	255	12.5	0.4
20PF-3	30.5	12	209	460	5.0	1.1
21PF-1A[1] or 21PF-1B[1]	[2]76.0	[2]30	2, 250	4, 950	5.0	5.0
21PF-1A[1] or 21Pf-1B[1]	[3]76.0	[3]30	2, 282	5, 020	5.0	5.0
21PF-2[1]	[2]76.0	[2]30	2, 250	4, 950	5.0	5.0
21PF-2[2]	[3]76.0	[3]30	2, 282	5, 020	5.0	5.0

[1] For 76 cm (30 in) cylinders, the maximum permitted H/U atomic ratio is 0.088.
[2] Model 30A inner cylinder (reference: ORO-651).
[3] Model 30B inner cylinder (reference: ORO-651).

§173.418 Authorized packages—pyrophoric Class 7 (radioactive) materials.
Pyrophoric Class 7 (radioactive) materials, as referenced in the §172.101 Table of this subchapter, in quantities not exceeding A_2 per package must be transported in DOT Specification 7A packagings constructed of materials that will not react with, nor be decomposed by, the contents. Contents of the package must be —

(a) In solid form and must not be fissile unless excepted by §173.453;

(b) Contained in sealed and corrosion resistant receptacles with positive closures (friction or slip-fit covers or stoppers are not authorized);

(c) Free of water and contaminants that would increase the reactivity of the material; and

(d) Inerted to prevent self-ignition during transport by either —
(1) Mixing with large volumes of inerting materials, such as graphite, dry sand, or other suitable inerting material, or blended into a matrix of hardened concrete; or
(2) Filling the innermost receptacle with an appropriate inert gas or liquid.

§173.419 Authorized packages—oxidizing Class 7 (radioactive) materials.
(a) An oxidizing Class 7 (radioactive) material, as referenced in the §172.101 Table of this subchapter, is authorized in quantities not exceeding an A_2 per package, in a DOT Specification 7A package provided that —
(1) The contents are:
(i) Not fissile;
(ii) Packed in inside packagings of glass, metal or compatible plastic; and
(iii) Cushioned with a material that will not react with the contents; and
(2) The outside packaging is made of wood, metal, or plastic.

(b) The package must be capable of meeting the applicable test requirements of §173.465 without leakage of contents.

(c) For shipment by air, the maximum quantity in any package may not exceed 11.3 kilograms (25 pounds).

§173.420 Uranium hexafluoride (fissile, fissile excepted and non-fissile).
(a) In addition to any other applicable requirements of this subchapter, uranium hexafluoride, fissile, fissile excepted or non-fissile, must be offered for transportation as follows:
(1) Before initial filling and during periodic inspection and test, packagings must be cleaned in accordance with American National Standard N14.1.
(2) Packagings must be designed, fabricated, inspected, tested and marked in accordance with —
(i) American National Standard N14.1 (1990, 1987, 1982, 1971) in effect at the time the packaging was manufactured;
(ii) Specifications for Class DOT-106A multi-unit tank car tanks (§§179.300 and 179.301 of this subchapter); or (iii) Section VIII, Division I of the ASME Code, provided the
packaging —
(A) Was manufactured on or before June 30, 1987;
(B) Conforms to the edition of the ASME Code in effect at the time the packaging was manufactured;
(C) Is used within its original design limitations; and
(D) Has shell and head thicknesses that have not decreased below the minimum value specified in the following table:

Packaging model	Minimum thickness; millimeters (inches)
1S, 2S	1.58 (0.062)
5A, 5B, 8A	3.17 (0.125)
12A, 12B	4.76 (0.187)
30B	7.93 (0.312)
48A, F, X, and Y	12.70 (0.500)
48T, O, OM, OM Allied, HX, H, and G	6.35 (0.250)

(3) Uranium hexafluoride must be in solid form.
(4) The volume of solid uranium hexafluoride, except solid depleted uranium hexafluoride, at 20°C (68° F) may not exceed 61% of the certified volumetric capacity of the packaging. The volume of solid depleted uranium hexafluoride at 20° C (68° F) may not exceed 62% of the certified volumetric capacity of the packaging.
(5) The pressure in the package at 20° C (68° F) must be less than 101.3 kPa (14.8 psia).

(b) Packagings for uranium hexafluoride must be periodically inspected, tested, marked and otherwise conform with the American National Standard N14.1-1990.

(c) Each repair to a packaging for uranium hexafluoride must be performed in accordance with American National Standard N14.1-1990.

§173.421 Excepted packages for limited quantities of Class 7 (radioactive) materials.
(a) A Class 7 (radioactive) material whose activity per package does not exceed the limits specified in §173.425 and its packaging are excepted from the specification packaging, marking, labeling and, if not a hazardous substance or hazardous waste, the shipping paper and certification requirements of this subchapter and requirements of this subpart if:
(1) Each package meets the general design requirements of §173.410;
(2) The radiation level at any point on the external surface of the package does not exceed 0.005 mSv/hour (0.5 mrem/ hour);
(3) The nonfixed (removable) radioactive surface contamination on the external surface of the package does not exceed the limits specified in §173.443(a);
(4) The outside of the inner packaging or, if there is no inner packaging, the outside of the packaging itself bears the marking ''Radioactive'';
(5) Except as provided in §173.426, the package does not contain more than 15 grams of uranium-235; and
(6) The material is otherwise prepared for shipment as specified in accordance with §173.422.

(b) A limited quantity of Class 7 (radioactive) material that is a hazardous substance or a hazardous waste, is not subject to the provisions in §172.203(d) or §172.204(c)(4) of this subchapter.

§173.422 Additional requirements for excepted packages containing Class 7 (radioactive) materials.
(a) Except for materials subject to the shipping paper requirements of subpart C of Part 172 of this subchapter, excepted packages prepared for shipment under the provisions of §173.421, §173.424, §173.426, or §173.428 must be certified as being acceptable for transportation by having a notice enclosed in or on the package, included with the packing list, or otherwise forwarded with the package. This notice must include the name of the consignor or consignee and one of the following statements, as appropriate:

(1) ''This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910'';

(2) ''This package conforms to the conditions and limitations specified in 49 CFR 173.424 for radioactive material, excepted package-instruments or articles, UN2910'';

(3) ''This package conforms to the conditions and limitations specified in 49 CFR 173.426 for radioactive material, excepted package-articles manufactured from natural or depleted uranium, or natural thorium, UN2910''; or

(4) ''This package conforms to the conditions and limitations specified in 49 CFR 173.428 for radioactive material, excepted package-empty package, UN2910.''

(b) An excepted package of Class 7 (radioactive) material that is classed as Class 7 and is prepared for shipment under the provisions of §173.421, §173.423, §173.424, §173.426, or §173.428 is not subject to the requirements of this subchapter, except for —

(1) Sections 171.15, 171.16, 174.750, 176.710, and 177.861 of this subchapter, pertaining to the reporting of incidents and decontamination, when transported by a mode other than air;

(2) Sections 171.15, 171.16, and 175.700(b) of this subchapter pertaining to the reporting of incidents and decontamination when transported by aircraft; and

(3) The training requirements of subpart H of part 172 of this subchapter and, for materials that meet the definition of a hazardous substance or a hazardous waste, the shipping paper requirements of subpart C of Part 172 of this subchapter.

§173.423 Requirements for multiple hazard limited quantity Class 7 (radioactive) materials.

(a) Except as provided in §173.4, when a limited quantity radioactive material meets the definition of another hazard class or division, it must be —

(1) Classed for the additional hazard;

(2) Packaged to conform with the requirements specified in §173.421(a)(1) through (a)(5) or §173.424(a) through (g), as appropriate; and

(3) Offered for transportation in accordance with the requirements applicable to the hazard for which it is classed.

(b) A limited quantity Class 7 (radioactive) material which is classed other than Class 7 in accordance with this subchapter is excepted from the requirements of §§173.422(a), 172.203(d), and 172.204(c)(4) of this subchapter if the entry ''Limited quantity radioactive material'' appears on the shipping paper in association with the basic description.

§173.424 Excepted packages for radioactive instruments and articles.

A radioactive instrument or article and its packaging is excepted from the specification packaging, shipping paper and certification, marking and labeling requirements of this subchapter and requirements of this subpart, if:

(a) Each package meets the general design requirements of §173.410;

(b) The activity of the instrument or article does not exceed the relevant limit listed in Table 7 in §173.425;

(c) The total activity per package does not exceed the relevant limit listed in Table 7 in §173.425;

(d) The radiation level at 10 cm (4 in) from any point on the external surface of any unpackaged instrument or article does not exceed 0.1 mSv/hour (10 mrem/hour);

(e) The radiation level at any point on the external surface of a package bearing the article or instrument does not exceed 0.005 mSv/hour (0.5 mrem/hour), or, for exclusive use domestic shipments, 0.02 mSv (2 mrem/hour);

(f) The nonfixed (removable) radioactive surface contamination on the external surface of the package does not exceed the limits specified in §173.443(a);

(g) Except as provided in §173.426, the package does not contain more than 15 grams of uranium-235; and

(h) The package is otherwise prepared for shipment as specified in §173.422.

§173.425 Table of activity limits—excepted quantities and articles.

The limits applicable to instruments, articles, and limited quantities subject to exceptions under §§173.421 and 173.424 are set forth in Table 7 as follows:

Table 7—Activity Limits for Limited Quantities, Instruments and Articles

Nature of contents	Instruments and articles		Materials package limits[1]
	Limits for each instrument or article[1]	Package limits[1]	
Solids:			
Special form	$10^{-2}A_1$	A_1	$10^{-3}A_1$
Normal form	$10^{-2}A_2$	A_2	$10^{-3}A_2$
Liquids:			
Tritiated water:			
< 0.0037 TBq/liter (0.1 Ci/L)			37 TBq (1,000 Ci)
0.0037 TBq to 0.037 TBq/L (0.1 Ci to 1.0 Ci/L)			3.7 TBq (100 Ci)
> 0.037 TBq/L (1.0 Ci/L)			0.037 TBq (1.0 Ci)
Other liquids	$10^{-3}A_2$	$10^{-1}A_2$	$10^{-4}A_2$
Gases:			
Tritium[2]	$2 \times 10^{-2}A_2$	$2 \times 10^{-1}A_2$	$2 \times 10^{-2}A_2$
Special form	$10^{-3}A_1$	$10^{-2}A_1$	$10^{-3}A_1$
Other forms	$10^{-3}A_2$	$10^{-2}A_2$	$10^{-3}A_2$

[1] For mixtures of radionuclides see §173.433(d).

[2] These values also apply to tritium in activated luminous paint and tritium adsorbed on solid carriers.

§173.426 Excepted packages for articles containing natural uranium or thorium.

A manufactured article in which the sole Class 7 (radioactive) material content is natural or unirradiated depleted uranium or natural thorium and its packaging is excepted from the specification packaging, shipping paper and certification, marking, and labeling requirements of this subchapter and requirements of this subpart if:

(a) Each package meets the general design requirements of §173.410;

(b) The outer surface of the uranium or thorium is enclosed in an inactive sheath made of metal or other durable protective material;

(c) The conditions specified in §173.421(a) (2), (3) and (4) are met; and

(d) The article is otherwise prepared for shipment as specified in §173.422.

§173.427 Transport requirements for low specific activity (LSA) Class 7 (radioactive) materials and surface contaminated objects (SCO).

(a) In addition to other applicable requirements specified in this subchapter, low specific activity (LSA) materials and surface contaminated objects (SCO), unless excepted by paragraph (d) of this section, must be packaged in accordance with paragraph (b) or (c) of this section and must be transported in accordance with the following conditions:

(1) The external dose rate must not exceed an external radiation level of 10 mSv/h (1 rem/h) at 3 meters from the unshielded material;

(2) The quantity of LSA and SCO material in any single conveyance must not exceed the limits specified in Table 9;

(3) LSA material and SCO that are or contain fissile material must meet the applicable requirements of §§173.451 and 173.467;

(4) Packages must meet the contamination control limits specified in §173.443;

(5) External radiation levels must comply with §173.441; and

(6) For LSA material and SCO required by this section to be consigned as exclusive use:

(i) Shipments must be loaded by the consignor and unloaded by the consignee from the conveyance or freight container in which originally loaded;

(ii) There must be no loose Class 7 (radioactive) material in the conveyance, however, when the conveyance is the packaging there must be no leakage of Class 7 (radioactive) material from the conveyance;

(iii) Packages must be braced so as to prevent shifting of lading under conditions normally incident to transportation;

(iv) Specific instructions for maintenance of exclusive use shipment controls must be provided by the offeror to the carrier. Such instructions must be included with the shipping paper information;

(v) Except for shipments of unconcentrated uranium or thorium ores, the transport vehicle must be placarded in accordance with subpart F of Part 172 of this subchapter;

(vi) For domestic transportation only, packages are excepted from the marking and labeling requirements of this subchapter. However, the exterior of each nonbulk package must be stenciled or otherwise marked ''Radioactive—LSA'' or ''Radioactive—SCO'', as appropriate, and nonbulk packages that contain a hazardous substance must also be stenciled or otherwise marked with the letters ''RQ'' in association with the above description; and

(vii) Except when transported in an industrial package in accordance with Table 8, transportation by aircraft is prohibited.

(b) Except as provided in paragraph (c) of this section, LSA material and SCO must be packaged as follows:

(1) In an industrial package (IP-1, IP-2 or IP-3; §173.411), subject to the limitations of Table 8;

(2) For domestic transportation only, in a DOT Specification 7A (§178.350 of this subchapter) Type A package. The requirements of §173.412 (a), (b), (c) and (k) do not apply;

(3) For domestic transportation only, in a strong, tight package that prevents leakage of the radioactive content under normal conditions of transport. In addition to the requirements of paragraph (a) of this section, the following requirements must be met:

(i) The shipment must be exclusive use;

(ii) The quantity of Class 7 (radioactive) material in each packaging may not exceed an A_2 quantity;

(4) For domestic transportation only, in a packaging that complies with the provisions of 10 CFR 71.52, and is transported in exclusive use; or

(5) Any Type B, B(U) or B(M) packaging authorized pursuant to §173.416.

(c) LSA-I and SCO-I (see §173.403), unless packaged in accordance with paragraph (b) of this section, must be packaged in bulk packagings in accordance with this paragraph. The shipment must be, in addition to complying with the applicable requirements of paragraph (a) of this section, exclusive use:

(1) *Solids.* Packages must be strong tight packagings, meeting the requirements of subpart B of this Part. The requirements of §173.410 do not apply.

(2) *Liquids.* Liquids must be transported in the following packagings:

(i) Specification 103CW, 111A60W7 (§§179.200, 179.201, 179.202 of this subchapter) tank cars. Bottom openings in tanks are prohibited; or

(ii) Specification MC 310, MC 311, MC 312, MC 331 or DOT 412 (§178.348 or §178.337 of this subchapter) cargo tank motor vehicles. Bottom outlets are not authorized. Trailer-on-flat-car service is not authorized.

(d) Except for transportation by aircraft, LSA material and SCO that conform to the provisions specified in 10 CFR 20.2005 are excepted from all requirements of this subchapter pertaining to Class 7 (radioactive) materials when offered for transportation for disposal or recovery. A material which meets the definition of another hazard class is subject to the provisions of this subchapter relating to that hazard class.

(e) LSA and SCO that exceed the packaging limits in this section must be packaged in accordance with 10 CFR part 71.

(f) Tables 8 and 9 are as follows:

Table 8—Industrial Package Integrity Requirements for LSA Material and SCO

Contents	Industrial packaging type	
	Exclusive use shipment	Nonexclusive use shipment
LSA-I:		
Solid	IP-1	IP-1
Liquid	IP-1	IP-2
LSA-II:		
Solid	IP-2	IP-2
Liquid and gas	IP-2	IP-3
LSA-III	IP-2	IP-3
SCO-I	IP-1	IP-1
SCO-II	IP-2	IP-2

Table 9—Conveyance Activity Limits for LSA Material and SCO

Nature of material	Activity limit for conveyances
LSA-I	No limit
LSA-II and LSA-III; noncombustible solids	No limit
LSA-II and LSA-III; combustible solids and all liquids and gases	100 A_2
SCO	100 A_2

§173.428 Empty Class 7 (radioactive) materials packaging.

A packaging which previously contained Class 7 (radioactive) materials and has been emptied of contents as far as practical, is excepted from the shipping paper and certification, marking and labeling requirements of this subchapter, and from requirements of this chapter, provided that —

(a) The packaging meets the requirements of §173.421(a), (2), (3), and (5) of this subpart;

(b) The packaging is in unimpaired condition and is securely closed so that there will be no leakage of Class 7 (radioactive) material under conditions normally incident to transportation;

(c) Internal contamination does not exceed 100 times the limits in §173.443(a);

(d) Any labels previously applied in conformance with Subpart E of Part 172 of this subchapter are removed, obliterated, or covered and the ''Empty'' label prescribed in §172.450 of this subchapter is affixed to the packaging; and

(e) The packaging is prepared for shipment as specified in §173.422.

§173.431 Activity limits for Type A and Type B packages.

(a) Except for LSA material and SCO, a Type A package may not contain a quantity of Class 7 (radioactive) materials greater than A_1 for special form Class 7 (radioactive) material or A_2 for normal form Class 7 (radioactive) material as listed in §173.435, or, for Class 7 (radioactive) materials not listed in §173.435, as determined in accordance with §173.433.

(b) The limits on activity contained in a Type B, Type B(U), or Type B(M) package are those prescribed in §§173.416 and 173.417, or in the applicable approval certificate under §§173.471, 173.472 or 173.473.

§173.433 Requirements for determining A_1 and A_2 values for radionuclides and for the listing of radionuclides on shipping papers and labels.

(a) Values of A_1 and A_2 for individual radionuclides that are the basis for many activity limits elsewhere in this subchapter are given in the table in §173.435.

(b) For individual radionuclides whose identities are known, but which are not listed in the table in §173.435, the determination of the values of A^1 and A_2 requires approval from the Associate Administrator for Hazardous Materials Safety except that the values of A_1 and A_2 in Table 10 may be used without obtaining approval from Associate Administrator for Hazardous Materials Safety.

(c) In calculating A_1 and A_2 values for a radionuclide not listed in the table in §173.435, a single radioactive decay chain in which the 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, will 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 will be those corresponding to the parent nuclide of that chain. Otherwise, the parent and daughter nuclides will be considered as a mixture of different nuclides.

(d) Mixtures of radionuclides whose identities and respective activities are known, must conform to the following conditions:

(1) For special form Class 7 (radioactive) material:

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

Where B(i) is the activity of radionuclide i and A_1 (i) is the A_1 value for radionuclide i; or

(2) For other forms of Class 7 (radioactive) material, either —

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

Where B(i) is the activity of radionuclide i and A_2 (i) is the A_2 value for radionuclide i; or

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

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.

(e) When the identity of each nuclide 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 (d) of this section. 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 or beta/gamma emitters, respectively.

(f) *Shipping papers and labeling.*

(1) For mixtures of radionuclides, the radionuclides (n) that must be shown on shipping papers and labels in accordance with §§172.203 and 172.403 of this subchapter, respectively, must be determined on the basis of the following formula:

$$\sum_{i=1}^{n} \frac{a_{(i)}}{A_{(i)}} \geq 0.95 \sum_{i=1}^{n+m} \frac{a_{(i)}}{A_{(i)}}$$

Where n + m represents all the radionuclides in the mixture, m are the radionuclides that do not need to be considered, a_i is the activity of radionuclide i in the mixture, and A_i is the A_1 or A_2 value, as appropriate for radionuclide i.

(g) Table 10 is as follows:

Table 10—General Values for A_1 and A_2

Contents	A_1		A_2	
	(TBq)	(Ci)	(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 relevant data are available	0.10	2.70	2×10^{-5}	5.41×10^{-4}

§173.434 Activity-mass relationships for uranium and natural thorium. The table of activity-mass relationships for uranium and natural thorium are as follows:

Specific Activity

Thorium and uranium enrichment[1] (Wt.% ^{235}U present)	Specific activity			
	TBo/gram	Grams/ Tbq	Ci/gram	Grams/Ci
0.45 (depleted)	1.9×10^{-8}	5.4×10^{7}	5.0×10^{-7}	2.0×10^{6}
0.72 (natural)	2.6×10^{-8}	3.8×10^{7}	7.1×10^{-7}	1.42×10^{6}
1.0	2.8×10^{-8}	3.6×10^{7}	7.6×10^{-7}	1.3×10^{6}
1.5	3.7×10^{-8}	2.7×10^{7}	1.0×10^{-6}	1.0×10^{6}
5.0	1.0×10^{-7}	1.0×10^{7}	2.7×10^{-6}	3.7×10^{5}
10.0	1.8×10^{-7}	5.6×10^{6}	4.8×10^{-6}	2.1×10^{5}
20.0	3.7×10^{-7}	2.7×10^{6}	1.0×10^{-5}	1.0×10^{5}
35.0	7.4×10^{-7}	1.4×10^{6}	2.0×10^{-5}	5.0×10^{4}
50.0	9.3×10^{-7}	1.1×10^{6}	2.5×10^{-5}	4.0×10^{4}
90.0	2.1×10^{-6}	4.7×10^{5}	5.8×10^{-5}	1.7×10^{4}
93.0	2.6×10^{-6}	3.9×10^{5}	7.0×10^{-5}	1.4×10^{4}
95.0	3.4×10^{-6}	3.0×10^{5}	9.1×10^{-5}	1.1×10^{4}
Natural thorium.	8.1×10^{-9}	1.2×10^{8}	2.2×10^{-7}	4.6×10^{6}

[1] The figures for uranium include representative values for the activity of uranium-234 which is concentrated during the enrichment process. The activity for thorium includes the equilibrium concentration of thorium includes the equilibrium concentration of thorium-228.

§173.435 Table of A_1 and A_2 values for radionuclides.
The table of A_1 and A_2 values for radionuclides is as follows:

Symbol of radionuclide	Element and atomic number	A_1(TBq)	A_1(Ci)	A_2(TBq)	A_1(Ci)	Specific activity (TBq/g)	Specific activity (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		0.6	16.2	0.4	10.8	8.4×10^{4}	2.2×10^{6}
Ag-105	Silver (47)	2	54.1	2	54.1	1.1×10^{3}	3.0×10^{4}
Ag-108m		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		0.6	16.2	0.5	13.5	5.8×10^{3}	1.6×10^{5}
Al-26	Aluminum (13)	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		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}	9.9×10^{4}
Ar-39		20	541	20	541	1.3	3.4×10^{1}
Ar-41		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		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		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}	2.1×10^{6}
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		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		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		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		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		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		0.4	10.8	0.4	10.8	4.0×10^{4}	1.1×10^{6}
C-11	Carbon (6)	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	Calcium (20)	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	Cadmium (48)	40	1080	1	27.0	9.6×10^{1}	2.6×10^{3}
Cd-113m		20	541	9×10^{-2}	2.43	8.3×10^{4}	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	Cerium (58)	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	Californium (98)	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	Chlorine (17)	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	Curium (96)	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^{5}
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}

Symbol of radionuclide	Element and atomic number	A_1(TBq)	A_1(Ci)	A_2(TBq)	A_1(Ci)	Specific activity	
						(TBq/g)	(Ci/g)
Co-55	Cobalt (27)	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	Chromium (24)	30	811	30	811	3.4×10^{3}	9.2×10^{4}
Cs-129	Cesium (55)	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	Copper (29)	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	Dysprosium (66)	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}
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	2.1×10^{-2}	5.4×100^{-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}	21.6×10^{-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}

Symbol of radionuclide	Element and atomic number	A_1(TBq)	A_1(Ci)	A_2(TBq)	A_1(Ci)	Specific activity	
						(TBq/g)	(Ci/g)
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-74		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		(*see* §173.433)		(*see* §173.433)			
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[c]	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}
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}	4.7×10^{-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 x 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}

Symbol of radionuclide	Element and atomic number	A_1(TBq)	A_1(Ci)	A_2(TBq)	A_1(Ci)	Specific activity	
						(TBq/g)	(Ci/g)
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	Plutonium (94)	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	Radium (88)	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	Rubidium (37)	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	Rhenium (75)	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	Rhodium (45)	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	Radon (86)	0.2	5.41	4×10^{-3}	0.108	5.7×10^{3}	1.5×10^{5}
Ru-97	Ruthenium (44)	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	Sulfur (16)	40	1080	2	54.1	1.6×10^{3}	4.3×10^{4}
Sb-122	Antimony (51)	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	Scandium (21)	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}
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	10800	0.2	5.41	3.9	1.1×10^{2}
Sm-145	Samarium (62)	20	541	20	541	9.8×10^{1}	2.610^{3}
Sm-147		Unlimited	Unlimited	Unlimited	Unlimited	8.510^{-10}	2.310^{-8}
Sm-151		40	1080	4	108	9.710^{-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	1.010^{-3}	2.810^{-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}

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						(TBq/g)	(Ci/g)
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	5.610^{-1}	1.5×10^{1}
Tb-158		1	27.0	0.7	18.9	5.610^{-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	Thorium (90)	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	Titanium (22)	0.5	13.5	0.2	5.41	6.4	1.7×10^{2}
Tl-200	Thallium (81.1)	0.8	21.6	0.8	21.6	2.2×10^{4}	6.0×10^{5}
Tl-201		10	270	10	270	7.9×10^{3}	2.1×10^{5}
Tl-202		2	54.1	2	54.1	2.0×10^{3}	5.3×10^{4}
Tl-204		4	108	0.5	13.5	1.7×10^{1}	4.6×10^{2}
Tm-167	Thulium (69)	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	Uranium (92)	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* §173.434)
U (enriched more than 5%)		10	270	1×10^{-3}	2.70×10^{-2}	—	(*see* §173.434)
U (depleted)		Unlimited	Unlimited	Unlimited	Unlimited	—	(*see* §173.434)
V-48	Vanadium (23)	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	Tungsten (74)	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	Xenon (54)	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	Yttrium (39)	2	54.1	2	54.1	1.7×10^{4}	4.5×10^{5}
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}

Symbol of radionuclide	Element and atomic number	A_1(TBq)	A_1(Ci)	A_2(TBq)	A_1(Ci)	Specific activity	
						(TBq/g)	(Ci/g)
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

[a] International shipments of Einsteinium require multilateral approval of A_1 and A_2 values.
[b] International shipments of Fermium require multilateral approval of A_1 and A_2 values.
[c] 20 Ci for Mo^{99} for domestic use.
MFP: For mixed fission products, use formula for mixtures or Table 10 in §173.433.

Note: The activity per gram of radionuclide quantities are technical information that might not provide a direct relationship between the activity and total mass of material contained in a package.

§173.441 Radiation level limitations.

(a) Except as provided in paragraph (b) of this section, each package of Class 7 (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/hour (200 mrem/hour) at any point on the external surface of the package, and the transport index does not exceed 10.

(b) A package which exceeds the radiation level limits specified in paragraph (a) of this section must be transported by exclusive use shipment, and the radiation levels for such shipment may 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 surfaces of the vehicle, including 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;

(3) 0.1 mSv/h (10 mrem/h) at any point 2 meters (6.6 feet) 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 as part of a radiation protection program that satisfies the requirements of subpart I of part 172 of this subchapter.

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

(d) Packages exceeding the radiation level or transport index prescribed in paragraph (a) of this section may not be transported by aircraft.

§173.442 Thermal limitations.

A package of Class 7 (radioactive) material must be designed, constructed, and loaded so that —

(a) The heat generated within the package by the radioactive contents will not, during conditions normally incident to transport, affect the integrity of the package; and

(b) The temperature of the accessible external surfaces of the loaded package will not, assuming still air in the shade at an ambient temperature of 38°C (100°F), exceed either —

(1) 50°C (122°F) in other than an exclusive use shipment; or

(2) 85°C (185°F) in an exclusive use shipment.

§173.443 Contamination control.

(a) The level of non-fixed (removable) radioactive contamination on the external surfaces of each package offered for transport must be kept as low as reasonably achievable. The level of non-fixed radioactive contamination may not exceed the limits set forth in Table 11 and must be determined by either:

(1) Wiping an area of 300 square centimeters of the surface concerned with an absorbent material, using moderate pressure, and measuring the activity on the wiping material. Sufficient measurements must be taken in the most appropriate locations to yield a representative assessment of the non-fixed contamination levels. The amount of radioactivity measured on any single wiping material, when averaged over the surface wiped, may not exceed the limits set forth in Table 11 at any time during transport; or (2) Using other methods of assessment of equal or greater efficiency, in which case the efficiency of the method used must be taken into account and the non-fixed contamination on the external surfaces of the package may not exceed ten times the limits set forth in Table 11, as follows:

Table 11—Non-Fixed External Radioactive Contamination—Wipe Limits

Contaminant	Maximum permissible limits		
	Bq/cm^2	uCi/cm^2	dpm/cm^2
Beta and gamma emitters and low toxicity alpha emitters	0.4	10^{-5}	22
All other alpha emitting radionuclides	0.04	10^{-6}	2.2

(b) Except as provided in paragraph (d) of this section, in the case of packages transported as exclusive use shipments by rail or public highway only, the removable (non-fixed) radioactive contamination on any package at any time during transport may not exceed ten times the levels prescribed in paragraph (a) of this section. The levels at the beginning of transport may not exceed the levels prescribed in paragraph (a) of this section.

(c) Except as provided in paragraph (d) of this section, each transport vehicle used for transporting Class 7 (radioactive) materials as an exclusive use shipment that utilizes the provisions of paragraph (b) of this section must be surveyed with appropriate radiation detection instruments after each use. A vehicle may not be returned to service until the radiation dose rate at each accessible surface is 0.005 mSv per hour (0.5 mrem per hour) or less, and there is no significant removable (non-fixed) radioactive surface contamination as specified in paragraph (a) of this section.

(d) Paragraphs (b) and (c) of this section do not apply to any closed transport vehicle used solely for the transportation by highway or rail of Class 7 (radioactive) material packages with contamination levels that do not exceed 10 times the levels prescribed in paragraph (a) of this section if—

(1) A survey of the interior surfaces of the empty vehicle shows that the radiation dose rate at any point does not exceed 0.1 mSv per hour (10 mrem per hour) at the surface or 0.02 mSv per hour (2 mrem per hour) at 1 meter (3.3 feet) from the surface;

(2) Each vehicle is stenciled with the words ''For Radioactive Materials Use Only'' in letters at least 76 millimeters (3 inches) high in a conspicuous place on both sides of the exterior of the vehicle; and

(3) Each vehicle is kept closed except for loading or unloading.

§173.444 Labeling requirements.
Each package of Class 7 (radioactive) materials, unless excepted by §173.421, §173.424, §173.426, 173.427 or §173.428, must be labeled as prescribed in Subpart E of Part 172 of this subchapter.

§173.446 Placarding requirements.
Placarding requirements are prescribed in Subpart F of Part 172 of this subchapter.

§173.447 Storage incident to transportation—general requirements.
The following requirements apply to temporary storage during the course of transportation but not to Nuclear Regulatory Commission or Agreement State-licensed facilities or U.S. Government-owned or contracted facilities.

(a) The number of packages bearing RADIOACTIVE YELLOW-II or RADIOACTIVE YELLOW-III labels stored in any one storage area, such as a transit area, terminal building, storeroom, waterfront pier, or assembly yard, must be limited so that the sum of the transport indexes in any individual group of packages does not exceed 50. Groups of these packages must be stored so as to maintain a spacing of at least 6 meters (20 feet) from other groups of packages containing Class 7 (radioactive) materials.

(b) Mixing of different kinds of Class 7 (radioactive) materials packages that include fissile materials packages is authorized only in accordance with §173.459.

§173.448 General transportation requirements.
(a) Each shipment of Class 7 (radioactive) materials must be secured to prevent shifting during normal transportation conditions.

(b) Except as provided in §§174.81, 176.83, and 177.848 of this subchapter, or as otherwise required by the competent authority in the applicable certificate, a package of Class 7 (radioactive) materials may be carried among packaged general cargo without special stowage provisions, if —

(1) The heat output in watts does not exceed 0.1 times the minimum package dimension in centimeters; or

(2) The average surface heat flux of the package does not exceed 15 watts per square meter and the immediately surrounding cargo is not in sacks or bags or otherwise in a form that would seriously impede air circulation for heat removal.

(c) Packages bearing labels prescribed in §172.403 of this subchapter may not be carried in compartments occupied by passengers, except in those compartments exclusively reserved for couriers accompanying those packages.

(d) Mixing of different kinds of packages that include fissile packages is authorized only in accordance with §173.459.

(e) No person shall offer for transportation or transport aboard a passenger-carrying aircraft any single package with a transport index greater than 3.0 or an overpack with a transport index greater than 3.0.

(f) No person shall offer for transportation or transport aboard a passenger-carrying aircraft any Class 7 (radioactive) material unless that material is intended for use in, or incident to, research, medical diagnosis or treatment.

(g) If an overpack is used to consolidate individual packages of Class 7 (radioactive) materials, the packages must comply with the packaging, marking, and labeling requirements of this subchapter, and the following:

(1) The overpack must be labeled as prescribed in §172.403 of this subchapter, except as follows:

(i) The ''contents'' entry on the label may state ''mixed'' unless each inside package contains the same radionuclide(s);

(ii) The ''activity'' entry on the label must be determined by adding together the number of Becquerels (curies) of the Class 7 (radioactive) materials packages contained therein;

(iii) For a non-rigid overpack, the required label together with required package markings must be affixed to the overpack by means of a securely attached, durable tag. The transport index must be determined by adding together the transport indexes of the Class 7 (radioactive) materials packages contained therein; and

(iv) For a rigid overpack, the transport index must be determined by:

(A) Adding together the transport indexes of the Class 7 (radioactive) materials packages contained in the overpack; or

(B) Except for fissile Class 7 (radioactive) materials, direct measurements as prescribed in §173.403 for transport index, taken by the person initially offering the packages contained within the overpack for shipment.

(2) The overpack must be marked as prescribed in Subpart D of Part 172 of this subchapter and §173.25(a).

(3) The transport index of the overpack may not exceed 3.0 for passenger-carrying aircraft shipments, or 10.0 for cargo-aircraft only shipments.

§173.451 Fissile materials—general requirements.
Except as provided in §173.453, each package containing fissile Class 7 (radioactive) materials must comply with §§173.457 and 173.459.

§173.453 Fissile materials—exceptions.
The requirements of §§173.451 through 173.459 do not apply to:

(a) A package containing 15 grams or less of fissile radionuclides. If the material is transported in bulk, the quantity limitation applies to the conveyance.

(b) A package containing homogeneous solutions or mixtures where:

(1) The minimum ratio of the number of hydrogen atoms to the number of atoms of fissile radionuclides (H/X) is 5200;

(2) The maximum concentration of fissile radionuclides is 5 grams per liter; and

(3) The maximum mass of fissile radionuclides in the package is 500 grams, except that for a mixture in which the total mass of plutonium and uranium-233 does not exceed 1% of the mass of uranium-235, the limit is 800 grams of uranium-235. If the material is transported in bulk, the quantity limitations apply to the conveyance.

(c) A package containing uranium enriched in uranium-235 to a maximum of 1% by mass, and mixed with a total plutonium and uranium-233 content of up to 1% of the mass of uranium-235, if the fissile radionuclides are distributed homogeneously throughout the package contents, and do not form a lattice arrangement within the package.

(d) A package containing not more than 5 grams of fissile radionuclides in any 10 liter volume, provided that the material is contained in packages that will maintain the limitation on fissile radionuclide distribution during normal conditions of transport.

(e) A package containing one kilogram or less of plutonium of which 20% or less by mass may consist of plutonium-239, plutonium-241, or any combination of those radionuclides.

(f) A package containing liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of 2% by mass, with total plutonium and uranium-233 content not exceeding 0.1% of the mass of uranium-235 with a nitrogen-to-uranium atomic ratio (N/U) of 2.

§173.457 Transportation of fissile material, controlled shipments—specific requirements.
Shipments of fissile material packages that have been assigned a transport index of greater than 10 for criticality control purposes in accordance with 10 CFR 71.59 must meet the requirements of this section and §173.441(a) or (b).

(a) For fissile material, controlled shipments, the offeror or carrier, as appropriate, must incorporate transportation controls which:

(1) Provide nuclear criticality safety;

(2) Protect against loading, storing, or transporting that shipment with any other fissile material; and

(3) Include in the shipping papers the description required by §172.203(d) of this subchapter.

(b) Fissile material, controlled shipments must be transported:

(1) In an exclusive use conveyance;

(2) Except for shipments by aircraft, in a conveyance with an escort having the capability, equipment, authority, and instructions to provide administrative controls necessary to assure compliance with this section;

(3) In a conveyance containing no other packages of any Class 7 (radioactive) material required to bear one of the labels prescribed in §172.403 of this

subchapter. Specific arrangements must be made between the offeror and the carrier, with instructions to that effect issued with the shipping papers; or

(4) Under any other procedure approved by the Associate Administrator for Hazardous Materials Safety in accordance with Part 107 of this subchapter.

§173.459 Mixing of fissile material packages.

(a) Mixing of fissile material packages with other types of Class 7 (radioactive) materials is authorized only if the transport index of any single package does not exceed 10 and the total transport index in any conveyance or storage location does not exceed 50.

(b) Fissile packages may be shipped with an external radiation level greater than 0.1 mSv/hr (10 mrem per hour) at 1 meter (3.3 feet), and combined with other packages of the same or different designs in a fissile material, controlled shipment, under the conditions prescribed in §173.457, if:

(1) Each package in the shipment has been assigned a transport index for criticality control purposes in accordance with the 10 CFR 71.59;

(2) The nuclear criticality control transport index does not exceed 10 for any single package;

(3) The total nuclear criticality control transport index does not exceed 100 for all packages in the shipment; and

(4) Except as provided in §176.704(e) of this subchapter, the shipment is not transported by vessel.

(c) A fissile material, controlled shipment of packages may be combined with other packages of the same or different design when each package has been assigned a nuclear criticality control transport index in accordance with 10 CFR 71.59, and may be combined with other fissile packages into a fissile material, controlled shipment under the conditions prescribed in §173.457, if:

(1) The nuclear criticality control transport index which has been assigned in the package approval does not exceed 50 for any single package;

(2) The total nuclear criticality control transport index for all packages in the shipment does not exceed 100; and

(3) Except as provided in §176.704(e) of this subchapter, the shipment is not transported by vessel.

§173.461 Demonstration of compliance with tests.

(a) Compliance with the test requirements in §§173.463 through 173.469 must be shown by any of the methods prescribed in this paragraph, or by a combination of these methods appropriate for the particular feature being evaluated:

(1) Performance of tests with prototypes or samples of the specimens representing LSA-III, special form Class 7 (radioactive) material, or packaging, in which case the contents of the packaging for the test must simulate as closely as practicable the expected range of physical properties of the radioactive contents or packaging to be tested, must be prepared as normally presented for transport. The use of non-radioactive substitute contents is encouraged provided that the results of the testing take into account the radioactive characteristics of the contents for which the package is being tested;

(2) Reference to a previous, satisfactory demonstration of compliance of a sufficiently similar nature;

(3) Performance of tests with models of appropriate scale incorporating those features that are significant with respect to the item under investigation, when engineering experience has shown results of those tests to be suitable for design purposes. When a scale model is used, the need for adjusting certain test parameters, such as the penetrator diameter or the compressive load, must be taken into account; or

(4) Calculations or reasoned evaluation, using reliable and conservative procedures and parameters.

(b) With respect to the initial conditions for the tests under §§173.463 through 173.469, except for the water immersion tests, compliance must be based upon the assumption that the package is in equilibrium at an ambient temperature of 38°C (100°F).

§173.462 Preparation of specimens for testing.

(a) Each specimen (i.e., sample, prototype or scale model) must be examined before testing to identify and record faults or damage, including:

(1) Divergence from the specifications or drawings;

(2) Defects in construction;

(3) Corrosion or other deterioration; and

(4) Distortion of features.

(b) Any deviation found under paragraph (a) of this section from the specified design must be corrected or appropriately taken into account in the subsequent evaluation.

(c) The containment system of the packaging must be clearly specified.

(d) The external features of the specimen must be clearly identified so that reference may be made to any part of it.

§173.463 Packaging and shielding—testing for integrity.

After each of the applicable tests specified in §§173.465 and 173.466, the integrity of the packaging, or of the packaging and its shielding, whichever is applicable, must be retained to the extent required by §173.412(j) for the packaging being tested.

§173.465 Type A packaging tests.

(a) The packaging, with contents, must be capable of withstanding the water spray, free drop, stacking and penetration tests prescribed in this section. One prototype may be used for all tests if the requirements of paragraph (b) of this section are met.

(b) *Water spray test.* The water spray test must precede each test or test sequence prescribed in this section. The water spray test must simulate exposure to rainfall of approximately 5 centimeters (2 inches) per hour for at least one hour. The time interval between the end of the water spray test and the beginning of the next test must be such that the water has soaked in to the maximum extent without appreciable drying of the exterior of the specimen. In the absence of evidence to the contrary, this interval may be assumed to be two hours if the water spray is applied from four different directions simultaneously. However, no time interval may elapse if the water spray is applied from each of the four directions consecutively.

(c) *Free drop test.* The specimen must drop onto the target so as to suffer maximum damage to the safety features being tested, and:

(1) The height of the drop measured from the lowest point of the specimen to the upper surface of the target may not be less than the distance specified in Table 12, for the applicable package mass. The target must be as specified in §173.465(c)(5). Table 12 is as follows:

Table 12—Free-Drop Distance for Testing Packages to Normal Conditions of Transport

Packaging mass	Free-drop distance	
Kilograms (pounds)	**Feet**	**Meters**
< Mass 5,000 (11,000)	1.2	4
5,000 (11,000) Mass to 10,000 (22,000)	0.9	3
10,000 (22,000) Mass to 15,000 (33,000)	0.6	2
> 15,000 (33,000) Mass	0.3	1

(2) For packages containing fissile material, the free drop test specified in paragraph (c)(1) of this section must be preceded by a free drop from a height of 0.3 meter (1 foot) on each corner, or in the case of cylindrical packages, onto each of the quarters of each rim.

(3) For fiberboard or wood rectangular packages with a mass of 50 kilograms (110 pounds) or less, a separate specimen must be subjected to a free drop onto each corner from a height of 0.3 meter (1 foot).

(4) For cylindrical fiberboard packages with a mass of 100 kilograms (220 pounds) or less, a separate specimen must be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 meter (1 foot).

(5) The target for the free drop test must be a flat, horizontal surface of such mass and rigidity that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase the damage to the specimen.

(d) *Stacking test.*

(1) The specimen must be subjected for a period of at least 24 hours to a compressive load equivalent to the greater of the following:

(i) Five times the mass of the actual package; or

(ii) The equivalent of 13 kilopascals (1.9 pounds per square inch) multiplied by the vertically projected area of the package.

(2) The compressive load must be applied uniformly to two opposite sides of the specimen, one of which must be the base on which the package would normally rest.

(e) *Penetration test.* For the penetration test, the specimen must be placed on a rigid, flat, horizontal surface that will not move significantly while the test is being performed.

(1) A bar of 3.2 centimeters (1.25 inches) in diameter with a hemispherical end and a mass of 6 kilograms (13.2 pounds) must be dropped and directed to fall with its longitudinal axis vertical, onto the center of the weakest part of the specimen, so that, if it penetrates far enough, it will hit the containment system. The bar may not be significantly deformed by the test; and

(2) The height of the drop of the bar measured from its lower end to the intended point of impact on the upper surface of the specimen must be 1 meter (3.3 feet) or greater.

§173.466 Additional tests for Type A packagings designed for liquids and gases.

(a) In addition to the tests prescribed in §173.465, Type A packagings designed for liquids and gases must be capable of withstanding the following tests:

(1) *Free drop test.* The packaging specimen must drop onto the target so as to suffer the maximum damage to its containment. The height of the drop measured from the lowest part of the packaging specimen to the upper surface of the target must be 9 meters (30 feet) or greater. The target must be as specified in §173.465(c)(5).

(2) *Penetration test.* The specimen must be subjected to the test specified in §173.465(e) except that the height of the drop must be 1.7 meters (5.5 feet).

§173.467 Tests for demonstrating the ability of Type B and fissile materials packagings to withstand accident conditions in transportation.

Each Type B packaging or packaging for fissile material must meet the test requirements prescribed in 10 CFR Part 71 for ability to withstand accident conditions in transportation.

§173.468 Test for LSA-III material.

(a) LSA-III Class 7 (radioactive) material must meet the test requirement of paragraph (b) of this section. Any differences between the material to be transported and the test material must be taken into account in determining whether the test requirements have been met.

(b) *Test method.*

(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 of 10 micromho/cm at 20°C (68°F).

(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.

§173.469 Tests for special form Class 7 (radioactive) materials.

(a) Special form Class 7 (radioactive) materials must meet the test requirements of paragraph (b) of this section. Each solid Class 7 (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. The following additional conditions apply:

(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; and

(4) After each test, leaktightness or indispersibility of the specimen must be determined by —

(i) A method no less sensitive than the leaching assessment 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 10^{-4} torr-1/s (1.3 $\pm 10^{-4}$ atm-cm^3/s) based on air at 25°C (77°F) and one atmosphere differential pressure for solid radioactive content, or 10^{-6} torr-1/s (1.3 x 10^{-6} atm-cm^3/s) for liquid or gaseous radioactive content; or

(ii) A specimen that comprises or simulates Class 7 (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.''

(b) *Test methods* —

(1) *Impact Test.* The specimen must fall onto the target from a height of 9 meters (30 feet) or greater. The target must be as specified in §173.465(c)(5).

(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 kilograms (3 pounds) through 1 meter (3.3 feet).

(ii) The flat face of the billet must be 2.5 centimeters (1 inch) in diameter with the edges rounded off to a radius of 3 millimeters ±0.3 millimeters (0.12 inch ±0.012 inch).

(iii) The lead must be of hardness number 3.5 to 4.5 on the Vickers scale and thickness 2.5 centimeters (1 inch) 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.

(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 centimeters (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 kilograms (3 pounds) through 1 meter (3.3 feet).

(v) The flat face of the billet must be 2.5 centimeters (1 inch) in diameter with the edges rounded off to a radius of 3 millimeters ±0.3 millimeters (0.12 inch ±0.012 inch).

(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 seven days in water at ambient temperature. The water must have a pH range of 6 to 8 and a maximum conductivity of 10 micromho per centimeter at 20°C (68°F).

(ii) The water with specimen must then be heated to a temperature of 50°C ±5° (122°F ±9°) and maintained at this temperature for four hours.

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

(iv) The specimen must then be stored for at least seven 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°C ±5 (122°F ±9°) and maintained at that temperature for four hours.

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

(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°C ±5° (122°F ±9°) and maintained at this temperature for four hours.

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

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

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

(vi) The activity determined in paragraph (c)(2)(iii) of this section may not exceed 2 kilobecquerels (0.05 microcurie).

(d) A specimen that comprises or simulates Class 7 (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''; 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.''

§173.471 Requirements for U.S. Nuclear Regulatory Commission approved packages.

In addition to the applicable requirements of the U.S. Nuclear Regulatory Commission (USNRC) and other requirements of this subchapter, any offeror of a Type B, Type B(U), Type B(M), or fissile material package that has been approved by the USNRC in accordance with 10 CFR part 71 must also comply with the following requirements:

(a) The offeror shall be registered with the USNRC as a party to the packaging approval, and make the shipment in compliance with the terms of the packaging approval;

(b) The outside of each package must be durably and legibly marked with the package identification marking indicated in the USNRC packaging approval;

(c) Each shipping paper related to the shipment of the package must bear the package identification marking indicated in the USNRC packaging approval;

(d) Before export shipment of the package, the offeror shall obtain a U.S. Competent Authority Certificate for that package design or if one has already been issued, the offeror shall register, in writing (including a description of the quality assurance program required by 10 CFR part 71) with the U.S. Competent Authority as a user of the certificate. (Note: The person who originally applies for a U.S. Competent Authority Certificate will be registered automatically.) Upon registration, the offeror will be furnished with a copy of the certificate. The offeror shall then submit a copy of the U.S. Competent Authority Certificate applying to that package design to the national competent authority of each country into or through which the package will be transported, unless the offeror has documentary evidence that a copy has already been furnished; and

(e) Each request for a U.S. Competent Authority Certificate as required by the IAEA regulations must be submitted in writing to the Associate Administrator for Hazardous Materials Safety. The request must be in triplicate and include copies of the applicable USNRC packaging approval, USNRC Quality Assurance Program approval number, and a reproducible 22 cm x 30 cm (8.5'' x 11'') drawing showing the make-up of the package. Each request is considered in the order in which it is received. To allow sufficient time for consideration, requests must be received at least 90 days before the requested effective date.

§173.472 Requirements for exporting DOT Specification Type B and fissile packages.
(a) Any offeror who exports a DOT Specification Type B or fissile material package authorized by §173.416 or §173.417 shall comply with paragraphs (b) through (f) of this section.

(b) The shipment must be made in accordance with the conditions of the U.S. Certificate of Competent Authority.

(c) The outside of each package must be durably and legibly marked with the package identification marking indicated in the U.S. Competent Authority Certificate.

(d) Each shipping paper related to the shipment of the package must bear the package identification marking indicated in the U.S. Competent Authority Certificate.

(e) Before export of the package, the offeror shall obtain a U.S. Competent Authority Certificate for that package design, or if one has already been issued, the offeror shall register in writing (including a description of the quality assurance program required by 10 CFR Part 71, subpart H, or 49 CFR 173.474 and 173.475) with the U.S. Competent Authority as a user of the certificate. Upon registration, the offeror will be furnished with a copy of the certificate. The offeror shall then submit a copy of the U.S. Competent Authority Certificate applying to that package design to the national competent authority of each country into or through which the package will be transported, unless the offeror has documentary evidence that a copy has already been furnished.

(f) Each request for a U.S. Competent Authority Certificate as required by IAEA regulations must be submitted in writing to the Associate Administrator for Hazardous Materials Safety. The request must be submitted in triplicate and must include a description of the quality assurance program required by 10 CFR Part 71, subpart H, or 49 CFR 173.474 and 173.475, and a reproducible 22 cm x 30 cm (8.5'' x 11'') drawing showing the make-up of the package. A copy of the USNRC quality assurance program approval will satisfy the requirement for describing the quality assurance program. Each request is considered in the order in which it is received. To allow sufficient time for consideration, requests must be received at least 90 days before the requested effective date.

§173.473 Requirements for foreign-made packages.
In addition to other applicable requirements of this subchapter, each offeror of a foreign-made Type B, Type B(U), Type B(M), or fissile material package for which a Competent Authority Certificate is required by IAEA's ''Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6,'' shall also comply with the following requirements:

(a) Prior to the shipment of such a package of Class 7 (radioactive) materials into or from the U.S., the offeror shall —
(1) Have the foreign competent authority certificate revalidated by the U.S. Competent Authority, unless this has been done previously. Each request for revalidation must be submitted in writing to the Associate Administrator for Hazardous Materials Safety. The request must be in triplicate, contain all the information required by Section VII of the IAEA regulations in Safety Series No. 6, and include a copy in English of the foreign competent authority certificate. Each request is considered in the order in which it is received. To allow sufficient time for consideration, requests must be received at least 90 days before the requested effective date;
(2) Register in writing with the U.S. Competent Authority as a user of the package covered by the foreign competent authority certificate and its U.S. revalidation. If the offeror is requesting the revalidation, registration is automatic; and
(3) Supply to the carrier, upon request, the applicable competent authority certificates. However, the competent authority certificates are not required to accompany the packages to which they apply.

(b) The outside of each package must be durably and legibly marked with the competent authority identification marking indicated on the Competent Authority Certificate and revalidation.

(c) Each shipping paper for a shipment of Class 7 (radioactive) materials must bear a notation of the package identification marking indicated on the competent authority certificate or revalidation.

(d) All requirements of the foreign competent authority certificate and the U.S. Competent Authority revalidation must be fulfilled.

§173.474 Quality control for construction of packaging.
Prior to the first use of any packaging for the shipment of Class 7 (radioactive) material, the offeror shall determine that —

(a) The packaging meets the quality of design and construction requirements as specified in this subchapter; and

(b) The effectiveness of the shielding, containment and, when required, the heat transfer characteristics of the package, are within the limits specified for the package design.

§173.475 Quality control requirements prior to each shipment of Class 7 (radioactive) materials.
Before each shipment of any Class 7 (radioactive) materials package, the offeror must ensure, by examination or appropriate tests, that —

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

(b) The packaging is in unimpaired physical condition, except for superficial marks;

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

(d) For fissile material, each moderator and neutron absorber, if required, is present and in proper condition;

(e) Each special instruction for filling, closing, and preparation of the packaging for shipment has been followed;

(f) Each closure, valve, or other opening of the containment system through which the radioactive content might escape is properly closed and sealed;

(g) Each packaging containing liquid in excess of an A_2 quantity and intended for air shipment has been tested to show that it will not leak under an ambient atmospheric pressure of not more than 25 kPa, absolute (3.6 psia). The test must be conducted on the entire containment system, or on any receptacle or vessel within the containment system, to determine compliance with this requirement;

(h) The internal pressure of the containment system will not exceed the design pressure during transportation; and

(i) External radiation and contamination levels are within the allowable limits specified in this subchapter.

§173.476 Approval of special form Class 7 (radioactive) materials.
(a) Each offeror of special form Class 7 (radioactive) materials must maintain on file for at least one year after the latest shipment, and provide to the Associate Administrator for Hazardous Materials Safety on request, a complete safety analysis, including documentation of any tests, demonstrating that the special form material meets the requirements of §173.469. An IAEA Certificate of Competent Authority issued for the special form material may be used to satisfy this requirement.

(b) Prior to the first export shipment of a special form Class 7 (radioactive) material from the United States, each offeror shall obtain a U.S. Competent Authority Certificate for the specific material. For special form material manufactured outside the United States, an IAEA Certificate of Competent Authority from the country of origin may be used to meet this requirement.

(c) Each request for a U.S. Competent Authority Certificate as required by the IAEA regulations must be submitted in writing, in triplicate, to the Associate Administrator for Hazardous Materials Safety. Each request is considered in the order in which it is received. To allow sufficient time for consideration, requests must be received at least 90 days before the requested effective date. Each petition for a U.S. Competent Authority Certificate must include the following information:
(1) A detailed description of the material, or if a capsule, a detailed description of the contents. Particular reference must be made to both physical and chemical states;
(2) A detailed statement of the capsule design and dimensions, including complete engineering drawings [22cm x 30cm (8-1/2 inches x 11 inches)] and schedules of material, and methods of construction;
(3) A statement of the tests that have been made and their results; or evidence based on calculative methods to show that the material is able to pass the tests; or other evidence that the special form Class 7 (radioactive) material complies with §173.469; and
(4) For the original request for a Competent Authority Certificate, evidence of a quality assurance program.

(d) Paragraphs (a) and (b) of this section do not apply in those cases where A_1 equals A_2 and the material is not required to be described on the shipping papers as ''Radioactive Material, Special Form, n.o.s.''

§173.477 Approval for export shipments.
(a) Each export shipment of a package for which an IAEA certificate of competent authority has been issued or revalidated in accordance with §173.471, §173.472, or §173.473 must have multilateral approval if the shipment includes:
(1) A vented Type B(M) package;
(2) A Type B(M) packaging containing Class 7 (radioactive) materials with an activity greater than 3×10^3 A_1, or 3×10^3 A_2, as appropriate, or 1000 TBq (27,000 curies), whichever is less;
(3) A shipment of packages containing fissile materials if the sum of the transport indices of the individual packages exceeds 50; or
(4) Transportation by special arrangement.

(b) Each application for shipment approval not under special arrangement must contain:
(1) The period of time for which the approval is sought;
(2) A description of the contents, the expected modes of transportation, the type of conveyance to be used, and the proposed route; and
(3) An explanation of how the special precautions and special administrative and operational controls referred to in the package design certificates are to be put into effect.

(c) Each application for shipment approval under special arrangement must contain:
(1) A statement of the reasons why the shipment cannot be made in accordance with the applicable requirements; and
(2) A statement of any special precautions or special administrative or operational controls that will be used during transport to ensure that the overall safety is at least equivalent to that provided by the applicable requirements.

(d) The packaging and shipment approvals may be combined into a single approval issued in accordance with §§173.471, 173.472 or 173.473.

(e) Approval by competent authorities is not required for packagings designed for materials covered by §§173.421 through 173.428 or for Type A packagings designed for non-fissile Class 7 (radioactive) materials.

§173.478 Notification to competent authorities for export shipments.
(a) Before the first export shipment of any packaging containing fissile materials packages exceeding 15 grams, or Class 7 (radioactive) materials exceeding A_1 or A_2, the offeror shall ensure that copies of each applicable competent authority certificate issued in accordance with §173.471, §173.472, or §173.473 have been submitted to the competent authority of each country through which or into which it is to be transported. Except as specified in §173.477, the offeror is not required to await an acknowledgment from the competent authority prior to shipping the Class 7 (radioactive) material, nor is the competent authority required to acknowledge receipt of the certificate.

(b) For each of the shipments described in this paragraph, the offeror shall notify the competent authority of each country through which or into which the shipment is to be transported. This notification must be received by each competent authority at least 7 days before the shipment starts for the following: an activity greater than 3×10^3 A_1, 3×10^3 A_2, as appropriate, or 1000 TBq (27,000 Curies), whichever is the least;
(2) Type B(M) packages; or
(3) Transportation by special arrangements.

(c) The offeror notification must include:
(1) Sufficient information to enable the packaging to be identified, including all applicable certificate numbers and identification marks;
(2) Information as to the date of shipment, the expected date of arrival, and the proposed routing;
(3) The name of the Class 7 (radioactive) material or nuclide;
(4) A description of the physical and chemical form of the Class 7 (radioactive) material; and
(5) The maximum activity of the Class 7 (radioactive) material, except that for fissile material, the mass of fissile material may be used instead of activity.

(d) The offeror is not required to send a separate notification if the required information has been included in the application for shipment approval.

Subpart J [Reserved]

Subpart K [Reserved]

Subpart L [Reserved]

Subpart M [Reserved]

Subpart N [Reserved]

Subpart O [Reserved]

Appendix A [Reserved]

Appendix B — Procedure for Testing Chemical Compatibility and Rate, of Permeation in Plastic Packaging and Receptacles
1. The purpose of this procedure is to determine the chemical compatibility and permeability of liquid hazardous materials packaged in plastic packaging and receptacles. Alternatives for this procedure are permitted as specified in §173.24(e)(3)(iii) of this subchapter.
2. Compatibility and rate of permeation are determined by subjecting full size plastic containers (or smaller containers as permitted in paragraph 4 of this Appendix) and hazardous material lading to one of the following combinations of time and temperature:
a. Test Method 1: 180 days at a temperature no lower than 18°C (64°F)
b. Test Method 2: 28 days at a temperature no lower than 50°°C (122°F)
c. Test Method 3: 14 days at a temperature no lower than 60°°C (140°F)
3. Regardless of which test method is used, at least three sample containers shall be tested for each combination of hazardous material and size and design of container. Fill containers to rated capacity with the specific hazardous material (at the concentration to be transported) and close as for shipment. For the first and last 24 hours of storage under the selected test method, place the containers with closures downward, except that containers fitted with a vent are so placed on each occasion for five minutes only.
4. For testing under Test Method 2 or 3 in those instances where it is not practicable to use full size containers, smaller containers may be used. The small