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Part II

Department of Transportation

**Research and Special Programs
Administration**

49 CFR Part 171 et al.

**Transportation Regulations; Compatibility
With Regulations of the International
Atomic Energy Agency; Notice of
Proposed Rule**

DEPARTMENT OF TRANSPORTATION**Research and Special Programs Administration**

49 CFR Parts 171, 172, 173, 174, 175, 176, 177, and 178

[Docket No. HM-169A; Notice No. 89-8]

RIN 2137-AB60

**Transportation Regulations;
Compatibility With Regulations of the
International Atomic Energy Agency**

AGENCY: Research and Special Programs Administration (RSPA), Department of Transportation (DOT).

ACTION: Notice of proposed rule (NPRM).

SUMMARY: This notice proposes to amend the Hazardous Materials Regulations (HMR) concerning radioactive material to make them compatible with those of the International Atomic Energy Agency (IAEA) and thus with those of most major nuclear nations of the world. Although several substantive changes are proposed to provide a more uniform degree of safety for various types of shipments, the basic standards for packaging radioactive material remain unchanged. The intended effect of this rulemaking is to increase the level of safety and facilitate international commerce as it relates to the transportation of radioactive materials. On June 8, 1988, the U.S. Nuclear Regulatory Commission (USNRC) published a corresponding proposed rule change (53 FR 21550) to its transportation regulations found in 10 CFR part 71.

DATES: Comments must be received on or before February 9, 1990.

ADDRESSES: Address comments to Dockets Unit, Office of Hazardous Materials Transportation, (DHM-30), U.S. Department of Transportation, Washington, DC 20590. Comments should be submitted, when possible, in five copies and should identify the docket. Persons wishing to receive confirmation of receipt of their comments should include a self-addressed stamped postcard. The Docket Unit is located in Room 8421 of the Nassif Building, 400 Seventh Street SW., Washington, DC 20590. Office hours are 8:30 a.m. to 5:00 p.m., Monday through Friday, except Federal holidays.

FOR FURTHER INFORMATION CONTACT: Michael E. Wangler, Chief, Radioactive Materials Branch, Technical Division, Office of Hazardous Materials Transportation, U.S. Department of

Transportation, 400 Seventh Street, SW., Washington, DC 20590, (202) 360-4545.

SUPPLEMENTARY INFORMATION:**I. Background**

In 1958, at the request of the Economic and Social Council of the United Nations, the IAEA undertook the development of international regulations for the safe transportation of radioactive materials. The initial regulations published by the IAEA in 1961 were recommended to member states as the basis for national regulations and for application to international transportation. As a result of extensive revision in 1963 and 1964, and further effort in 1968, a version of the IAEA "Regulations for Safe Transport of Radioactive Materials, Safety Series No. 6" was published in 1967. The IAEA regulations have since been adopted generally by most nations of the world as a basis for their own national regulations governing the transportation of radioactive materials.

Since 1968, the U.S. Nuclear Regulatory Commission (USNRC) (formerly the Atomic Energy Commission (AEC)) has issued regulations which are substantially in conformance with IAEA standards for fissile radioactive materials and large quantities of radioactive materials. In October 1968 the Hazardous Materials Regulation Board of DOT published amendments which were also in substantial conformance with the 1967 IAEA standards (Docket HM-2, 33 FR 14918).

In February 1969, recognizing that the international standards should be revised from time to time on the basis of scientific and technical advances, as well as accumulated experience in their application, the IAEA invited its member states to submit comments and suggested changes to the regulations. Other goals of this IAEA procedure were to remove any ambiguities and to simplify the presentation of the text of the regulations.

Within the U.S., comments and suggested revisions to the IAEA regulations were collected by DOT from the AEC, the American National Standards Institute (ANSI), the Atomic Industrial Forum and others. As a result of that effort, a compilation of approximately 40 comments was forwarded by DOT to the IAEA in July 1969. Some of those suggested changes were intended to more closely align U.S. regulations with the IAEA regulations.

In 1970 the IAEA convened a panel of experts to review the regulations and consider the comments which had been submitted by member states. As a result

of this review panel's efforts and additional revisions, the Director General of the IAEA (Director General) transmitted a third revision draft to all IAEA member states and to interested international organizations.

In January 1971, the Office of Hazardous Materials of the DOT published a public notice (36 FR 1280) in the form of a "Request for Public Advice on Revisions of International Regulations." Interested persons thereby were informed of the issuance and availability of this third revised draft, identified as IAEA Document No. PL-383, entitled "Regulations for the Safe Transport of Radioactive Materials, Third Revised Draft, November 1970".

In cooperation with the AEC, the DOT solicited comments on this third draft. Copies were distributed to all AEC operating contractors, as well as the Atomic Industrial Forum and ANSI Subcommittee N14 (Transportation of Fissile and Radioactive Materials) for redistribution to their members and other interested persons. Formal U.S. comments on the third draft were forwarded by DOT to the IAEA through the Department of State.

A final Review Panel of experts was convened by the IAEA in October 1971, to finalize the revisions. As a result of that Panel, the IAEA subsequently issued its "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials 1973 Revised Edition," in late 1973. Subsequent to the issuance of the 1973 Edition of IAEA Safety Series No. 6, the IAEA convened another Review Panel in December 1974. The purpose of this Panel was to consider any minor inconsistencies, omissions or errors that were revealed in the course of national and international applications to the IAEA's 1973 Revised Standards, and to recommend, among other things, any changes in details that should be made in the regulations under the established procedures of the IAEA Board of Governors.

As a result of the 1974 Review Panel work, the IAEA developed a list of minor drafting changes to the 1973 Revised Edition of Safety Series No. 6, which became effective in May 1975, as well as a list of substantive proposed changes under the "90-day" amendment procedure. These latter changes were adopted in 1977 by the IAEA.

At its first meeting in October 1978, IAEA's Standing Advisory Group for the Safe Transport of Radioactive Materials (SAGSTRAM), established by the Director General in October 1977, reviewed and recommended a small number of additional amendments, some

of which slightly modified the changes issued by the IAEA in 1977. The recommendations of SAGSTRAM were subsequently published by the Director General as the "1973 Revised Edition, As Amended."

On March 10, 1983, RSPA published Docket HM-169 (48 FR 10218), which revised the HMR relating to the transportation of radioactive materials. That revision, in combination with a parallel revision of 10 CFR part 71 administered by the USNRC, brought United States domestic transport safety regulations at the Federal level in accord with relevant portions of the IAEA design and performance requirements to the extent considered feasible. This action made U.S. regulations compatible with the domestic regulations of most of the international community.

At the time of the 1971 Review Panel, a decision was made that periodic review of Safety Series No. 6 should be carried out at intervals of about 10 years to assure that the requirements were kept current. As a result, a review was initiated in 1979 to fulfill this commitment for periodic evaluation.

As in the past, the IAEA solicited comments and proposals for changes from member states and international organizations. Based on more than 200 pages of comments, the IAEA convened a Review Panel for the comprehensive review of Safety Series No. 6 considering changes in transport conditions and methods used for shipping radioactive materials. The Review Panel was again composed of the major countries involved in radioactive material transportation. The Review Panel was asked to strike a balance between keeping the regulations reasonably the same for continuity and ease of application and making necessary changes as a result of experience gained in their application. Two additional panel meetings produced a draft document that was issued in 1985 by the IAEA as the "1985 Edition" of Safety Series No. 6. Minor changes to the 1985 edition were made in 1986. Docket HM-169 was written to incorporate, to the extent possible, some of the changes anticipated in the 1985 version of Safety Series No. 6.

At its Fifth Meeting in 1986 SAGSTRAM recommended that Safety Series No. 6 undergo revision every ten years for major changes, and that minor changes and changes of detail be made at two-year intervals to ensure that it remains current with technology and needs. Minor changes are promulgated by the Director General without specific member state acceptance; changes of detail are subject to the "90 day" rule in

which members states are given the opportunity to submit their acceptance or rejection of individual changes of detail. These recommendations were accepted by the Director General.

To initiate the revision process, the IAEA in 1988 again solicited comments and proposals for changes to the regulations and to its supporting documents. A Technical Committee was convened in 1987 to review the member state submittals, to determine which submittals warranted consideration and to assign each submittal to the appropriate category of change. Given the recommendations of this Technical Committee, the Director General promulgated the minor changes and submitted the changes of detail under the "90 day" rule. The changes were accepted by the member states and were published as "Supplement 1988" to the 1985 edition of Safety Series No. 6.

This notice proposes to revise the HMR, as it relates to the transportation of radioactive materials, so that it is in essential conformance with the 1985 edition of Safety Series No. 6 and the Supplement 1988. These revisions to the HMR are necessary to allow for the international transportation of radioactive materials to and from the United States.

II. Discussion of Changes

While this notice proposes an extensive revision of that portion of the regulations dealing with the transportation of radioactive materials, the majority of the changes are not substantive in nature. Many changes involve revision of section and paragraph numbers and their references and the use of the International System of Units (SI units) for radiological measurements where appropriate. In addition, a few sections are proposed to be rewritten to provide clarity without changing their subject matter. Although not all of subpart I of part 173 of 49 CFR, entitled "Radioactive Materials", has been proposed to be changed, it has been reprinted in its entirety for ease of understanding. Substantive changes are discussed in the following paragraphs.

Radiation Protection

On January 27, 1987, the Environmental Protection Agency (EPA) published a document titled, "Radiation Protection Guidance to Federal Agencies for Occupational Exposure: Recommendations Approved by the President." This document updated radiation guidance to Federal agencies. The recommendations are provided to Federal agencies to enable them to revise or develop detailed standards and regulations in those areas for which

they have regulatory or administrative jurisdiction. As the lead Federal agency in this area, the EPA will monitor Federal agency compliance with the recommendations, will provide clarification and interpretation, as appropriate, to reflect new information, and will promote the necessary coordination to achieve an effective Federal program of worker protection.

Among its recommendations, the EPA specifies that no exposure should occur unless an overall benefit will be derived from the activity causing the exposure; that radiation dose should be maintained as low as it is reasonably achievable (ALARA); that the annual effective dose equivalent be limited to 50 milliSieverts (5 rems) to the whole body, 150 milliSieverts (15 rems) to lens of the eye, and 500 milliSieverts (50 rems) to any other organ, tissue or extremity of the body; that occupation exposure for individuals under the age of 18 not exceed $\frac{1}{10}$ of values recommended for radiation workers; and that the dose equivalent to an unborn child as a result of the occupational exposure of a woman who has declared herself to be pregnant should not exceed 5 milliSieverts (500 millirem) during the entire gestation period. Since this proposal only summarizes EPA's recommendations, the full text should be obtained from EPA for study.

RSPA proposes to incorporate the EPA recommendations into the HMR. The HMR would incorporate the EPA document by reference, would require that an ALARA program be established, and would limit radiation exposures to those specified in the EPA recommendations. The HMR would also provide for a three-tier approach for developing a radiation protection program to monitor the dose to any worker exposed to radiation for meeting the recommendations of the EPA guidance. For annual effective dose equivalents not exceeding 5 milliSieverts (500 millirem), a shipper or carrier would not be required to provide any detailed monitoring program for the workers. However, the shipper or carrier would be responsible for periodically evaluating operations to ensure that no activity would cause an annual dose to exceed 5 milliSieverts (500 millirem). For operations which will cause an annual dose of between 5 milliSieverts (500 millirem) and 15 milliSieverts (1.5 rems), the shipper or carrier would be required to perform periodic assessments of radiation exposure levels for each worker in this range to determine if controls to limit exposure should be implemented or if

constant personnel exposure monitoring is required. For operations which will cause an annual dose of between 15 milliSieverts (1.5 rems) and 50 milliSieverts (5 rems), a radiation exposure monitoring program for each individual would be implemented. Programs would be able to satisfy this latter requirement through the issuance and monitoring of individual personnel exposure devices on a monthly or quarterly basis.

The promulgation of a radiation protection program will bring the HMR in line with other Federal agencies which control the radiation exposure of occupationally exposed individuals. For example, under the Atomic Energy Act of 1954, as amended, the USNRC limits the radiation exposure of individuals who are employed by its licensees. Similarly, the Department of Energy under this same Act conducts a radiation protection program for its employees meeting the requirements of the Federal guidance.

General Design Requirements for All Packages

As proposed, certain packagings used for the transportation of radioactive materials would be required to have greater integrity. Excepted packages are currently required to meet the requirements only for a strong, tight package. Under the proposal, all packages of radioactive materials, including excepted packages, would be required to meet general design requirements prescribed in § 173.410. These packages would be required to be designed for ease of handling and proper restraint during shipment. They would be required to be free of protuberances and easily decontaminated. They would be required to be capable of withstanding the effects of vibration during transport. They also would be required to meet reduced pressure and temperature requirements. Minimum design requirements for excepted packages will increase the overall integrity of the packages.

Low Specific Activity Material and Surface Contaminated Objects

The IAEA has been working to update its requirements for shipment of low specific activity material (LSA) to provide for the transportation of irradiated and contaminated parts and equipment from decommissioned nuclear plants. The IAEA adopted a new designation for radioactive material called surface contaminated object (SCO). Unlike LSA, which requires a uniform distribution of radioactive material within the material, SCO is not

inherently radioactive but is superficially contaminated. Not every conceivable type of radioactive material that is removed from a facility during the decommissioning process will be covered by this proposal. New materials can be added to the SCO definition as needed. RSPA and USNRC concur with the IAEA in recognizing the need to issue regulations for the transportation of this specific type of material.

New LSA and SCO regulations consist of the following:

1. An expansion of the LSA definition to include new types of material;
2. A new definition of "surface contaminated object" (SCO) which is treated in a manner similar to LSA material; and
3. An increase of specific activity limits for nondispersible, nonrespirable forms of LSA material while at the same time limiting the quantity of LSA material which can be shipped in other than a Type B package. The package quantity limit is intended to limit external radiation levels produced as a result of shielding loss in a transportation accident.

In the past, overlapping statutory authority between the USNRC and DOT for regulating the transportation of radioactive material has created some confusion about which agency had regulatory authority for packages containing LSA. To clarify regulatory authority in this area, the current proposal establishes RSPA regulatory authority for packages containing LSA and SCO materials in amounts not exceeding 2 times the A_1 value ($2A_1$) for the specific nuclide being transported. Above that level the USNRC will assume regulatory responsibility.

Although the proposed regulations establish $2A_1$ as the level of contained radioactive material above which the USNRC regulations become applicable, the corresponding IAEA standard is expressed as an external radiation level at 3 meters from the unshielded material or object of 10 milliSievert/hr (1 rem/hr). The value A_1 for any specified radionuclide is the quantity of that radionuclide as a point source which produces a radiation level of 10 milliSieverts/hr (1 rem/hr) at a distance of 3 meters. Considering that LSA and SCO materials are bulk sources with considerable self-shielding, the value $2A_1$ was chosen by RSPA and the USNRC as a close approximation of the IAEA standard of 10 milliSieverts/hr (1 rem/hr) at 3 meters. This approach will make U.S. regulations inconsistent with those of IAEA, but little impact in international transportation should be experienced.

A new type of package, called the "industrial package", is being proposed for the handling of low specific activity material (LSA) and surface contaminated objects (SCO). Three categories of industrial packages (IP) IP-1, IP-2 and IP-3 are being proposed; each would have to meet differing packaging requirements. These packages would replace the modified Type A package, that is currently required for nonexclusive use shipments; and the strong, tight package, that is currently permitted for exclusive use shipments. For nonexclusive use shipments, the packaging requirements for LSA would not be substantially changed. The proposed provision would allow a shipper to determine the acceptable industrial package as based on the type of LSA or SCO to be shipped. In most cases, existing LSA packages could continue to be used. Certain lower hazard LSA and SCO could be shipped in a package equivalent to an excepted package. For exclusive use shipments, the industrial package would be required to meet minimum design requirements that are currently required for all packaging except for excepted packages. However, based on the type of LSA or SCO to be shipped, the shipper would have some flexibility in the design of the package.

This proposal is intended to produce an overall increase in the integrity of the packaging used for LSA and SCO. It will also ensure that industrial packages produced in the U.S. can be used in international commerce with a minimum of delay in shipment.

Expansion of Radionuclide List and Changes in Radionuclide Limits

Based on numerous proposals for additions to the table of radionuclides, in which limits are listed for the quantity of radioactive material in a single package, IAEA concluded that its table needed to include all radionuclides which have the potential for transportation. As a result, the table in § 173.435, which provides A_1 and A_2 values, has been expanded from 284 entries to 378 entries. Because there now should be few instances where unlisted radionuclides would be transported, the rules for calculating values for unlisted radionuclides would be simplified. The determination of limits for unlisted radionuclides, except for very conservative values, would be made subject to RSPA approval.

The preamble to the 1983 revision of the HMR (46 FR 10218) noted that the IAEA had replaced its concept of transport groups with a system of A_1 and A_2 values determining the package

type needed to transport radioactive materials. The A_1 and A_2 values are the maximum quantities of a particular radionuclide permitted in Type A packages in special form and normal form, respectively. Type A packages are those which provide adequate containment, shielding, and criticality control under normal conditions of transport and minor accidents, but are not designed to survive severe transportation accidents. Accident-resistant packages are identified as Type B. Radioactive material in special form is either a nondispersible solid or an encapsulated source to minimize the dispersibility and, therefore, the radiological hazard of the radioactive material. This system of limiting the radioactive content of Type A packages to A_1 and A_2 values depending on the dispersibility of the contents is the regulatory scheme for limiting the potential radiological hazard of a serious transportation accident involving packages of radioactive material.

The IAEA has since modified the system for determining A_1 and A_2 values. Although this system is based on achieving essentially the same limitations on potential accident radiological hazards as its predecessor system, the new system has the following advantages:

1. It states more clearly the radiation protection criteria employed;
2. It incorporates the data and conclusions on metabolic pathways provided during the years 1977-1981 by the International Commission on Radiological Protection (ICRP)
3. It includes dosimetric routes through human organs not previously considered; and
4. It harmonizes IAEA regulations with ICRP recommendations on radiological safety in Publications ICRP26 and ICRP-30.

The effect of IAEA's adoption of this new system for calculating A_1 and A_2 values, and the subsequent incorporation of the new values in the HMR, is that most current A_1 and A_2 values would be amended. Of the 284 radionuclide entries in section 173.435, A_2 values would be raised in 129 cases and lowered in 95 cases. Of the A_1 values, 144 would be raised and 73 lowered.

The new IAEA system for calculating A_1 and A_2 values is described in Appendix I, "The Q System for the Calculation of A and A Values," of IAEA Safety Series No. 7, "Explanatory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (1985 Edition)."

Classification of Fissile Material

As a result of the evolution of the fissile material criteria, IAEA recognized that the current three fissile classes could be combined and simplified into a single system. The effect of the simplification of the IAEA system now being proposed for U.S. regulations is:

1. Elimination of the three fissile class designations;
2. Establishment of a single set of criteria for all packages of fissile materials;
3. Use of the transport index as the primary control of accumulations of packages in transport under nearly all conditions.

Review by Section

Section 172.203(d) would be revised to add references to SI units; References to Fissile Class III would be replaced with "Fissile Material, Controlled Shipments"; and for LSA and SCO shipments appropriate group notations would be required on shipping papers.

Section 172.310 would be amended to require the trefoil symbol, as specified in Appendix B to part 172, to be marked on packages of radioactive material.

Section 172.403 would be amended to add reference to SI unit.

Paragraph (c)(17) of Appendix B to part 172 would be amended to note size requirements for the trefoil symbol on package markings labels and placards.

A new § 173.402, "SI units", would be added to phase in the use of the International System of Units (SI) for radiological measurements; that is, levels currently expressed in the customary units of rems and curies could be expressed in SI equivalents of Sieverts and Becquerels or customary units. The proposed revisions to the HMR use SI units followed by the customary units in parentheses. In many cases the limits in customary units have been extended to 3 significant figures so they represent a functional equivalent to the limits expressed in SI units. Limits on length, pressure, weight, and temperature are also expressed in SI units with functionally equivalent values in customary units following in parentheses. The objective of this approach is to maintain consistency with international regulations while allowing U.S. shippers to use the units with which they are most familiar. These changes would be made throughout the HMR.

Section 173.403 "Definitions", would be amended as follows:

- Contamination would be defined;
- Fissile material would be defined as the listed radionuclides, and the

definition would delete reference to §173.455;

—The definition of low-specific-activity (LSA) material would be extensively changed to correspond to that of IAEA. The one remaining significant difference would be the addition of a provision in the HMR for transportation of contaminated earth in a closed vehicle in unpackaged form. Extensive removal of contaminated earth has been found necessary in decommissioning facilities in the United States;

—A new definition for industrial packages (IP) providing for three classifications, IP-1, IP-2, and IP-3, to be used for the transport of LSA and SCO in quantities not to exceed 2A₁;

—The grandfather clause for special form radioactive material encapsulation would be updated; and

—A new definition of Surface Contaminated Object (SCO) would be added to correspond to the parallel definition in IAEA regulations. SCO would be treated in the regulations similarly to LSA materials, with industrial packaging required for most applications.

A new §173.404, "U.S. Competent Authority", which specifies the address of the U.S. Competent Authority for the transport of radioactive materials, would be added for ease of reference.

A new §173.405, "General Radiation Protection Principles", would be added to implement a requirement for the establishment of radiation protection programs as follows:

—Radiation exposures of transport workers would be subject to the recommendations specified in EPA's "Radiation Protection Guidance to Federal Agencies for Occupational Exposure";

—Radiation exposures would be maintained as low as is reasonably achievable (ALARA);

—Transport workers who are exposed to radiation would have to be given appropriate training concerning the hazards of radiation. On July 26, 1989, RSPA published in the Federal Register (54 FR 31144) an NPRM, entitled "Training for Hazardous Materials Transportation", under Docket HM-126F which proposed new training requirements for those persons involved in the transportation of hazardous materials. If and when this proposal and HM-126F become final rules, RSPA will make the necessary editorial changes to assure regulatory consistency;

—The annual effective dose equivalent of transport workers exposed to radiation would be limited to 50 milliSieverts (5 rems), which additional

limits of 150 milliSieverts (15 rems) for exposure of the lens of the eye and 500 milliSieverts (50 rems) for exposure of any other organ, tissue, or extremity of the body;

—Effective dose equivalent to an unborn child would be restricted to 5 milliSieverts (500 millirems); and

—Radiation exposures would be subject to a graded approach for actions to be used to control radiation. This approach would be determined by the magnitude and likelihood of exposure.

Section 173.410, "General design requirements", would be amended as follows:

—A package would have to be capable of withstanding the effects of acceleration, vibration or vibration resonance during transport;

—The materials of the packaging and any components would have to be chemically and physically compatible;

—All values through which the package contents could escape would have to be protected; and

—A package intended for air transport would have to be designed to withstand reduced temperature and pressure during transport;

—A package would be required to have a minimum dimension of 10 cm. (4 inches).

A new §173.411, "Additional design requirements for industrial packages", would be added to specify the requirements for IP-1, IP-2, and IP-3 packages. The IP-1 would have to meet the general design requirements for all packages designed for the transportation of radioactive material. An IP-2 would have to meet the requirements for an IP-1, as well as being subjected to free drop and compression tests specified for a Type A package. An IP-3 would have to meet the requirements for a Type A package for non-liquids.

Section 173.412, "Additional design requirements for Type A packages" would be amended to permit all packages containing liquids to use a double containment system. This would eliminate the current small package prohibition of this practice as well as requiring that expansion of liquids during temperature changes considered during design. This section would also be amended to include a closure requirement on containment systems that are separate unit of the packaging.

A new §173.414, "Authorized industrial packages", would be added to permit the use of IM 101 and IM 102 portable tanks and freight containers as industrial packages.

Section 173.415, "Authorized Type A packages", would be amended to eliminate the reference to DOT Specification 55 packaging, which has

not been authorized since July 1, 1985. This section would also be amended to permit the use of Type A packaging that also meets the requirements of the USNRC for fissile materials packaging.

Section 173.416, "Authorized Type B packages", would be amended to eliminate the reference to the DOT Specification 55 packaging. This would also eliminate the use of DOT Specification 55 packaging as an inner container for DOT Specification 20WC and 21WC overpacks.

Section 173.417, "Authorized packaging—fissile materials", would be amended to eliminate references to different fissile classes and to remove a direct reference to authorized packaging for 500 grams of Uranium 235 and 320 grams of plutonium through a cross-reference to the USNRC regulations. In addition, § 173.417(a)(8) and (b)(5) specify the authorized packagings for Type A and Type B, respectively, quantities of fissile radioactive material. Section 173.417(b)(5)(iii) limits the amount of uranium hexafluoride in a package to the amount specified in "Table 6—Authorized Quantities Of Uranium Hexafluoride (UF₆) As Fissile Class II" (Table 6). In Table 6, however, only DOT specifications 20PF-1 and 20PF-2 are authorized to contain a Type B quantity of uranium hexafluoride. Therefore, § 173.417(b)(5) would be revised to authorize only the DOT specifications 20PF-1 and 20PF-2 for the transportation of Type B quantities of uranium hexafluoride.

Section 173.421-1, "Excepted packages for limited quantities of radioactive material" would be amended to require compliance with the design requirements of § 173.410.

Section 173.421-1, "Additional requirements for excepted packages", would be amended to incorporate new proper shipping names and new UN identification numbers for excepted packages.

Section 173.422, "Excepted packages for instruments and articles," would be amended to require that the instrument or article be marked with the word "radioactive".

Section 173.423, "Table of activity limits—excepted quantities and articles", would be amended to remove the direct reference to tritiated water.

Section 173.425, "Transport requirements for low specific activity material (LSA) and surface contaminated objects (SCO)", would be amended to limit the activity in any LSA or SCO package to 2A₁, and to specify the appropriate industrial package for LSA and SCO transport in a new Table 8, "Industrial package integrity

requirements for LSA material and SCO."

Section 173.433, "Requirements for determination of A₁ and A₂ values for radionuclides", would be completely amended to incorporate a less complex method for calculating the A₁ and A₂ values.

Section 173.435, "Table for A₁ and A₂ values for radionuclides", would be amended to incorporate new A values as specified in the IAEA regulations.

Section 173.447, "Storage incident to transportation—general requirements", would be amended to delete references to fissile classes.

Section 173.448, "General transportation requirements", would be amended to delete references to fissile classes.

Section 173.453, "Fissile materials—exceptions", would be amended by deleting the exception for thermal reactor irradiated uranium and for thorium or uranium with not more than 0.72% fissile material.

Section 173.455, "Classification of fissile materials packages", would be deleted entirely because of the elimination of fissile classes.

Section 173.457, "Transportation of fissile material, controlled shipment—requirements", would redefine fissile class III shipments in terms of a new fissile material, controlled shipment.

Section 173.459, "Mixing of fissile materials packages", would be amended to delete references to fissile classes and express shipment controls in terms of fissile material, controlled shipments.

Section 173.461, "Demonstration of compliance with tests", would be amended to clarify that surrogate materials would be used in packaging to demonstrate compliance with the performance requirements for the package.

Section 173.469, "Tests for special form radioactive material", would be amended to add an alternative method to qualify special form radioactive material under the specific impact and temperature tests prescribed in the specified standard of the ISO.

A new § 173.470, "Test for LSA-III material", would be added to specify a leak test to examine the solid nature of the material for qualification of the material as LSA-III.

Section 173.471, "Requirements for U.S. Nuclear Regulatory Commission Approved packages", would be amended to require that the applicant submit a description, to RSPA, of the quality assurance program in effect during the design, manufacture, testing, documentation, use, maintenance, and

inspection of the package as required by the IAEA.

Section 173.472, "Requirements for exporting DOT Specification Type B and fissile packages", would be amended to require that the applicant submit a description, to RSPA, of the quality assurance program in effect during the design, manufacture, testing, documentation, use, maintenance, and inspection of the package as required by the IAEA.

Section 173.476, "Approval of special form radioactive materials", would be amended to require that the applicant provide evidence of the quality assurance program in effect during the design, manufacture, testing, documentation, use, maintenance, and inspection of the package as required by the IAEA.

Section 173.477, "Approval for export shipments", would be amended to delete references to fissile classes. Additionally, a new subparagraph specifying the contents of an application for shipment approval under special arrangement would be addressed.

Section 173.478, "Notification to competent authorities for export shipments", would be amended to delete references to fissile classes and would require additional information to be submitted to other national competent authorities for special arrangement shipments. Specifically, a notification of a special arrangement shipment will be required to include the name of the radionuclide, a description of the physical and chemical form, and the activity of the material.

In the modal requirements, parts 174 through 177, those sections involving radioactive material transportation would be updated to reflect the proposed changes in parts 171 through 173. Some of these proposed changes include the addition of metric and SI units and changes in regulatory references. In addition, those proposed changes to part 177, entitled "Carriage by Public Highway", will also be incorporated into a future rulemaking being developed by RSPA which will propose to recodify part 177.

II. Administrative Notices

A. Executive Order 12291

The RSPA has determined that this proposed rule (1) is not "major" under Executive Order 12291; (2) is not "significant" under DOT's regulatory policies and procedures (44 FR 11034); (3) will not affect not-for-profit enterprises or small governmental jurisdictions; and (4) does not require an environmental impact statement under the National Environmental Policy Act

(42 U.S.C. 4321 *et seq.*). A preliminary regulatory evaluation is available for review in the Docket.

B. Executive Order 12612

This action has been analyzed in accordance with the principles and criteria contained in Executive Order 12612, and it has been determined that the proposed rule does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

C. Impact on Small Entities

Based on limited information concerning size and nature of entities likely to be affected, I certify that the proposed regulation will not have a significant economic impact on a substantial number of small entities under criteria of the Regulatory Flexibility Act.

D. Paperwork Reduction Act

Information collection requirements contained in this proposal, which are additional to those already approved, are being submitted to the Office of Management and Budget for approval under the provisions of the Paperwork Reduction Act of 1980 (Public Law 96-511).

List of Subjects

49 CFR Part 171

Exports, Hazardous materials transportation, Hazardous waste, Imports, Incorporation by reference, Reporting and recordkeeping requirements.

49 CFR Part 172

Hazardous materials transportation, Hazardous waste, Labeling, Packaging and containers, Reporting and recordkeeping requirements.

49 CFR Part 173

Hazardous materials transportation, Packaging and containers, Radioactive materials, Reporting and recordkeeping requirements.

49 CFR Part 174

Hazardous materials transportation, Rail carriers, Radioactive materials.

49 CFR Part 175

Air carriers, Hazardous materials transportation, Radioactive materials, Reporting and recordkeeping requirements.

49 CFR Part 176

Hazardous materials transportation, Maritime carriers, Radioactive materials, Reporting and recordkeeping requirements.

49 CFR Part 177

Hazardous materials transportation, Motor carriers, Radioactive materials, Reporting and recordkeeping requirements.

49 CFR Part 178

Hazardous materials transportation, Packaging and containers, Reporting and recordkeeping requirements.

In consideration of the foregoing, 49 CFR part 171 through 178 would be amended as follows:

PART 171—GENERAL INFORMATION, REGULATIONS, AND DEFINITIONS

1. The authority citation for part 171 would continue to read as follows:

Authority: 49 App. U.S.C. 1802, 1803, 1804, 1808, 49 CFR part 1.

2. In § 171.7, paragraph (d)(10), (d)(16)(ii) and (d)(24) would be revised and paragraphs (c)(36) and (d)(34) would be added, to read as follows:

§ 171.7 Matter incorporated by reference.

(c) * * *
(36) USEPA: United States Environmental Protection Agency, Washington, DC 20460.

(d) * * *
(10) IAEA "Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6, 1985 Edition" including "Supplement 1988".

(16) * * *
(ii) USDOE, ORO-651 is titled, "Uranium Hexafluoride Handling Procedures and Container Descriptions," Revision 5, 1987 edition.

(24) International Organization for Standardization (ISO):

(i) "ISO 82-1974(e) Steel-Tensile Testing," First Edition 1974-08-01.

(ii) ISO/TR4826-1979(E), "Sealed radioactive sources—Leak test methods."

(iii) ISO 2919-1980(E), "Sealed radioactive sources—Classification."

(iv) ISO 1496/1-1978, "Series 1 Freight Containers—Specifications and Testing—Part 1: General Cargo Containers."

(34) U.S. Environmental Protection Agency, "Radiation Protection Guidance to Federal Agencies for Occupational Exposure: Recommendations Approved by the President", published in the Federal Register January 27, 1987 (52 FR 2822).

3. In § 171.12, paragraph (e) introductory text and paragraph (e)(4) would be revised to read as follows:

§ 171.12 Import and export shipments.

(e) Radioactive materials being imported into or exported from the United States, or passing through the United States in the course of being shipped between places outside the United States, may be offered and accepted for transportation when packaged, marked, labeled and

otherwise prepared for shipment in accordance with IAEA "Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6, 1985 Edition" including "Supplement 1988", if:

(4) The country of origin for the shipment has adopted the IAEA "Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6, 1985 Edition", including "Supplement 1988"; and

PART 172—HAZARDOUS MATERIALS TABLES AND HAZARDOUS MATERIALS COMMUNICATION REGULATIONS

4. The authority citation for part 172 would continue to read as follows:

Authority: 49 App. U.S.C. 1803, 1804, 1805, 1808; 49 CFR part 1, unless otherwise noted.

5. The following entries in the Hazardous Materials Table in § 172.101, would be added or removed, as indicated:

172.101 Hazardous Materials Table

(1) + /A/W	(2) Hazardous materials descriptions and proper shipping names	(3) Hazard Class	(3A) Identification number	(4) Label(s) required (if not excepted)	(5) Packaging		(6) Maximum net quantity in one package		(7) Water shipments		
					(a) Exceptions	(b) Specific requirements	(a) Passenger carrying aircraft or railcar	(b) Cargo only aircraft	(a) Cargo vessel	(b) Passenger vessel	(C) Other requirements
	ADD Radioactive material, excepted package—articles manufactured from natural or depleted uranium or natural thorium.	Radioactive material.	UN 2910	None	173.421-1 173.424	173.421-1 173.424			1.2	1.2	
	Radioactive material, excepted package—empty packaging.	.....do.....	UN 2910	Empty	173.421 173.421-1 173.427	173.421-1 173.427			1.2	1.2	
	Radioactive material, excepted package—instrument or articles.	.....do.....	UN 2910	None	173.421-1 173.422	173.421-1 173.422			1.2	1.2	
	Radioactive material, excepted package—limited quantity, n.o.s.	.....do.....	UN 2910	None	173.421 173.421-1	173.421 173.421-1			1.2	1.2	
	Radioactive material, surface contaminated object (SCO).	.....do.....	UN 2913	Radioactive	173.421 173.422 173.424	173.425			1.2	1.2	
	Uranium hexafluoride fissile excepted or non-fissile.	.....do.....	UN 2978	Radioactive and corrosive.	173.421	173.420 173.425			1.2	1.2	
	REMOVE Radioactive material, articles, manufactured from natural or depleted uranium or natural thorium.	.....do.....	UN 2909	None	173.421-1	173.421-1	No limit	No limit	1.2	1.2	

(1) +I/A/W	(2) Hazardous materials descriptions and proper shipping names	(3) Hazard Class	(3A) Identification number	(4) Label(s) required (if not excepted)	(5) Packaging		(6) Maximum net quantity in one package		(7) Water shipments		
					(a) Exceptions	(b) Specific requirements	(a) Passenger carrying aircraft or railcar	(b) Cargo only aircraft	(a) Cargo vessel	(b) Passenger vessel	(c) Other requirements
	Radioactive material, empty packages.	.....do.....	UN 2908.....	Empty.....	173.421-1 173.427	173.421-1 173.427			1,2	1,2	
	Radioactive material, instruments and articles.	.....do.....	UN 2911.....	None.....	173.421-1 173.422	173.421-1 173.422			1,2	1,2	
	Radioactive material, limited quantity, n.o.s.	.....do.....	UN 2910.....	None.....	173.421 173.421-1	173.421 173.421-1			1,2	1,2	
	Uranium hexafluoride, low specific activity.	.....do.....	UN 2978.....	Radioactive and corrosive	173.421-2	173.420 173.425			1,2	1,2	

6. In § 172.203, paragraphs (d)(1)(iii) and (d)(1)(vi) would be revised and paragraphs (d)(1)(ix) and (d)(1)(x) would be added to read as follows:

§ 172.203 Additional description requirements.

- (d) * * *
- (1) * * *

(iii) The activity contained in each package of the shipment in terms of the appropriate SI units (e.g. Becquerel, Terrabecquerel, etc.) or in terms of the appropriate SI units and customary units (e.g. Curies, millicuries, etc.). Abbreviations are authorized. For the shipment of a package containing a highway route controlled quantity of radioactive materials see § 173.403 of this subchapter) the words "Highway route controlled quantity" must be entered in association with the basic description.

(vi) For a shipment of fissile radioactive materials:

(A) The words "Fissile Excepted" if the package is excepted pursuant to § 173.453 of this subchapter, or

(B) If not exempt, the words "Fissile Materials;" and

(C) For a fissile material, controlled shipment, the additional notation: "Warning—Fissile Material, Controlled Shipment. Do not Load More Than * * * Packages per Vehicle." (Asterisks to be replaced by appropriate number.) "In loading and Storage Areas, Keep at Least 6 Meters (20 Feet) from Other Packages Bearing Radioactive Labels."

(D) If a fissile material, controlled shipment is to be transported by water, the supplementary notation must also include the following statement: "For shipment by water, only one fissile

material, controlled shipment is permitted in each hold."

(ix) For a shipment of low specific activity material or surface contaminated objects, the appropriate group notation of LSA-I, LSA-II, LSA-III, SCO-I, or SCO-II.

(x) For a shipment consigned as exclusive use, the statement "Exclusive Use Shipment".

7. Section 172.310 would be revised to read as follows:

§ 172.310 Radioactive materials.

In addition to any other markings required by this subpart, each package containing radioactive materials must be marked as follows:

(a) Each package of radioactive materials in excess of 50 kilograms (110 pounds) must have its gross weight plainly and durably marked on the outside of the package.

(b) Each package of radioactive materials which conforms to the requirements for Type A or Type B packaging (§ 173.403 of this subchapter) must be plainly and durably marked on the outside of the package in letters at least 13 mm (0.5 inch) high, with the words "TYPE A" or "TYPE B" as appropriate. A packaging which is not in compliance with these requirements may not be so marked.

(c) Each package of radioactive materials destined for export shipment must also be marked "USA" in conjunction with the specification marking, or other package certificate identification. (See §§ 173.471, 173.472, and 173.473 of this subchapter.)

(d) Each package of radioactive materials which conforms to the requirements for Type B, Type B(U) or

Type B(M) packaging must be plainly and durably marked on the outside of the package with a radiation symbol that conforms to the requirements of paragraph 1.(c)(17) of Appendix B to Part 172.

§ 172.400 [Amended]

8. In § 172.400, paragraph (b)(10) would be removed and reserved.

9. In § 172.403, paragraphs (b), (c) and (g)(2) would be revised to read as follows:

§ 172.403 Radioactive material.

(b) The proper label to affix to a package of radioactive material is based on the radiation level at the surface of the package and the transport index (§ 173.403 of this subchapter). The proper category of label must be determined in accordance with paragraph (c) of this section. The label to be applied must be the highest category required for any of the two determining conditions for the package. Radioactive White-I is the lowest category and Radioactive Yellow-III is the highest. For example: a package with a transport index of 0.8 and a maximum surface radiation level of 0.6 millisievert (60 millirems) per hour must bear a Radioactive Yellow-III label.

(c) Category of Label to be Applied to Radioactive Materials Packages:

Transport Index	Maximum radiation level at any point on external surface	Label category ¹
0 *	Not more than 0.005 mSv/h (0.5 mrem/h).	WHITE-I

Transport Index	Maximum radiation level at any point on external surface	Label category ¹
More than 0 but not more than 1.	More than 0.005 mSv/h (0.5 mrem/h) but not more than 0.5 mSv/h (50 mrem/h).	YELLOW-II.
More than 1 but not more than 10.	More than 0.005 mSv/h (0.5 mrem/h) but not more than 2 mSv/h (200 mrem/h).	YELLOW-III.
More than 10....	More than 2 mSv/h (200 mrem/h) but not more than 10 mSv/h (1,000 mrem/h).	YELLOW-III (Must be shipped under exclusive use provisions).

¹ Any package containing a "highway route controlled quantity" (§ 173.403 of this subchapter) must be labeled as Radioactive Yellow-III.

² If the measured TI is not greater than 0.05, the value quoted may be zero.

(g) * * * * *

(2) "Activity". Activity units must be expressed in appropriate SI units (e.g., Becquerels (Bq), Terabecquerels (TBq), etc.) or in appropriate SI units (e.g., Becquerels (Bq), Terabecquerels (TBq), etc.) and appropriate customary units

(Curies (Ci), millicuries (mCi), microCuries (uCi), etc.). Abbreviations are authorized. For fissile material, the weight in grams or kilograms of the fissile radionuclide may be inserted instead of activity units.

10. In § 172.407, paragraph (k) would be added to read as follows:

§ 172.407 Label specifications.

(k) The trefoil symbol on the RADIOACTIVE WHITE-I, RADIOACTIVE YELLOW-II, and RADIOACTIVE YELLOW-III labels must meet the appropriate specifications in paragraph 1. (c)(17) of Appendix B to part 172.

§ 172.504 [Amended]

11. In Table 1 of § 172.504, the entry "RADIOACTIVE AND CORROSIVE." in the second column would be revised to read "RADIOACTIVE AND CORROSIVE." and the fifth footnote would be revised to read as follows:

* For exclusive use shipments (see § 173.403) of low specific activity radioactive materials and surface contaminated objects transported in accordance with § 173.425(g).

12. In § 172.507, paragraph (a) would be revised to read as follows:

§ 172.507 Special placarding provisions: Highway.

(a) Each motor vehicle used to transport a package of highway route controlled quantity radioactive materials (see § 173.403 of this subchapter) must have the required RADIOACTIVE warning placard placed on a square background as described in § 172.527.

13. In appendix B to part 172, paragraph 1.(c)(17) would be revised to read as follows:

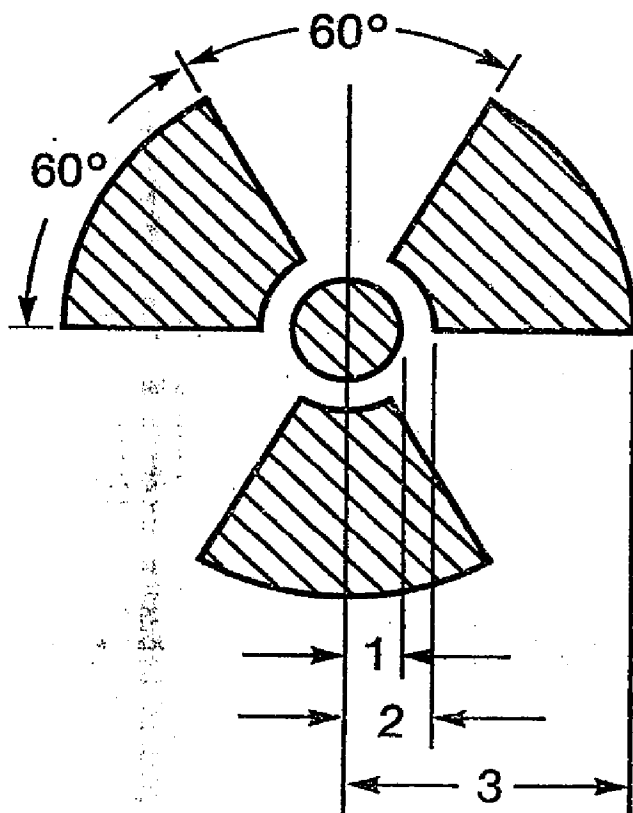
Appendix B-Dimensional Specification for Placards

1. * * * * *

(c) * * * * *

(17) RADIOACTIVE placard. The word "RADIOACTIVE" must be centered on the placard horizontal center line in letters 50.8 mm. (2 in.) with an 8.7 mm. (11/32-in.) stroke. The lower edge of the yellow triangle must be 28.6 mm. (1 1/8 in.) above the placard horizontal center line. The lower edge of the symbol must be 31.7 mm. (1.25 in.) above the placard horizontal center line. The symbol must be made as shown with the following dimensions:

BILLING CODE 4910-60-M



1 = Radius of Circle—
Minimum Dimensions
4 mm (0.16 inch) for marking
5 mm (0.2 inch) for labels
12.5 mm (0.5 inch) for placards

2 = 2 Radii

3 = 5 Radii

The lower white area must have a 3.2 mm. (1/8-inch) black solid line border extended from the edge of the yellow area to indicate the outer 12.7 mm. (1/2 in.) white placard border. The hazard class must be shown in numerals measuring at least 41.0 mm. (1.62 in.) in height. The placard color must be yellow, black, and white.

PART 173—SHIPPERS—GENERAL REQUIREMENTS FOR SHIPMENTS AND PACKAGINGS

14. The authority citation for part 173 would continue to read as follows:

Authority: 49 U.S.C. 1803, 1804, 1805, 1806, 1807, 1808; 49 CFR part 1, unless otherwise noted.

15. Subpart I of part 173 would be revised to read as follows:

Subpart I—Radioactive Materials

- 173.401 Scope.
- 173.402 SI units.
- 173.403 Definitions.
- 173.404 U.S. Competent Authority.
- 173.405 General radiation protection principles.
- 173.410 General design requirements.
- 173.411 Additional design requirements for industrial packages.
- 173.412 Additional design requirements for Type A packages.
- 173.413 Requirements for Type B packages.
- 173.414 Authorized industrial packages.
- 173.415 Authorized Type A packages.
- 173.416 Authorized Type B packages.
- 173.417 Authorized fissile materials packages.
- 173.418 Authorized packages—pyrophoric radioactive materials.
- 173.419 Authorized packages—oxidizing radioactive materials.
- 173.420 Uranium hexafluoride (fissile, fissile excepted and non-fissile).
- 173.421 Excepted packages for limited quantities of radioactive materials.
- 173.421-1 Additional requirements for excepted packages containing radioactive materials.
- 173.421-2 Requirements for multiple hazard limited quantity radioactive materials.
- 173.422 Excepted packages for instruments and articles.
- 173.423 Table of activity limits—excepted quantities and articles.
- 173.424 Excepted packages for articles containing natural uranium or thorium.
- 173.425 Transport requirements for low specific activity (LSA) radioactive materials and surface contaminated objects (SCO).
- 173.427 Empty radioactive materials packaging.
- 173.431 Activity limits for Type A and Type B packages.
- 173.433 Requirements for determinations of A_1 and A_2 values for radionuclides.
- 173.434 Activity-mass relationships for uranium and natural thorium.
- 173.435 Table of A_1 and A_2 values for radionuclides.
- 173.441 Radiation level limitations.
- 173.442 Thermal limitations.

- 173.443 Contamination control.
- 173.444 Labeling requirements.
- 173.446 Placarding requirements.
- 173.447 Storage incident to transportation—general requirements.
- 173.448 General transportation requirements.
- 173.451 Fissile materials—general requirements.
- 173.453 Fissile materials—exceptions.
- 173.457 Transportation of fissile material, controlled shipments—specific requirements.
- 173.459 Mixing of fissile material packages.
- 173.461 Demonstration of compliance with tests.
- 173.462 Preparation of specimens for testing.
- 173.463 Packaging and shielding—testing for integrity.
- 173.465 Type A packaging tests.
- 173.466 Additional tests for Type A packagings designed for liquids and gases.
- 173.467 Tests for demonstrating the ability of Type B and fissile materials packagings to withstand accident conditions in transportation.
- 173.468 Test for LSA-III material.
- 173.469 Tests for special form radioactive materials.
- 173.470 Tests for LSA material.
- 173.471 Requirements for U.S. Nuclear Regulatory Commission approved packages.
- 173.472 Requirements for exporting DOT Specification Type B and fissile packages.
- 173.473 Requirements for foreign-made packages.
- 173.474 Quality control for construction of packaging.
- 173.475 Quality control requirements prior to each shipment of radioactive materials.
- 173.476 Approval of special form radioactive materials.
- 173.477 Approval for export shipments.
- 173.478 Notification to competent authorities for export shipments.

Subpart I—Radioactive Materials

§ 173.401 Scope

(a) This subpart sets forth requirements for the packaging and transportation of radioactive materials by carriers and shippers subject to this subchapter. The requirements prescribed in this subpart are in addition to, not in lieu of, other requirements set forth in this subchapter and in 16 CFR Part 71 for the packaging and transportation of radioactive materials.

- (b) This subpart does not apply to:
- (1) Radioactive materials produced, used, transported, or stored within an establishment other than during the course of transportation.
 - (2) Radioactive materials contained in a medical device, such as a heart pacemaker, which is implanted in a human being or live animal.

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

§ 173.402 SI units.

To ensure compatibility with international transportation standards, all limits in this Subpart are given in terms of dual units. The International System of Units (SI) (metric) units are given first and are followed by U.S. standard or customary units in parentheses. The SI units are intended to serve as the standard. The U.S. customary units may not be exact equivalents, but are rounded, where appropriate, to a convenient value that provides a functionally equivalent limit.

§ 173.403 Definitions.

In this subpart:

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

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

Closed transport vehicle means a transport vehicle equipped with a securely attached exterior enclosure that during normal transportation restricts the access of unauthorized persons to the cargo space containing the 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 ends.

Containment system means the assembly of components of the packaging intended to retain the radioactive contents during transportation. "Contamination" means the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm² (10⁻⁶ microcuries/cm²) for beta and gamma emitters and low toxicity alpha emitters, or 0.04 Bq/cm² (10⁻⁶ microcuries/cm²) for all other alpha emitters. Low toxicity alpha emitters are (1) natural uranium, depleted uranium, natural thorium uranium-235, uranium-138, thorium-232, thorium-228 and thorium-230, when contained in ores, or physical or chemical concentrates or (2) alpha emitters with a half-life of less than days.

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

Fissile material means plutonium-238, plutonium-239, plutonium-241, uranium-233, uranium-235, or any combination of these radionuclides. Unirradiated natural uranium and depleted uranium, and natural uranium or depleted uranium which has been irradiated in thermal reactors only are not included in this definition. Certain exclusions are provided in § 173.453.

Fissile material, controlled shipment means any shipment that contains one or more packages that have been assigned 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 radioactive material;

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

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

Limited quantity of radioactive material means a quantity of radioactive material not exceeding the materials package limits specified in § 173.423 and conforming with requirements specified in § 173.421.

Low specific activity material (LSA) means radioactive material with limited specific activity that satisfies the descriptions and limits set forth below. Shielding materials surrounding the LSA material must not be considered in determining the estimated average specific activity of the package contents. LSA material must be in one of three groups:

(1) LSA-I

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

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

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

(iv) Contaminated soil in a closed transport vehicle for which the estimated average specific activity does not exceed $10^{-6}A_2/g$.

(2) LSA-II

(i) Water with tritium concentration up to 0.8 TBq/l (20 Ci/l); or

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

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

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

(ii) The radioactive material is relatively insoluble, or it is intrinsically contained in a relatively insoluble material, so that, even under loss of packaging, the loss of radioactive material per package by leaching when placed in water for seven days as determined by the tests prescribed in § 173.470 would not exceed 0.1 A_2 ; and

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

(iv) The solid will be of such a nature that if the entire contents of a package were subjected to the test specified in § 173.468 of this subchapter, the activity in the water would not exceed 0.1 A_2 .

Multilateral approval means approval of the package or shipment by the relevant competent authority of the country of origin and of each country through or into which the shipment is to be transported. This definition does not mean to imply approval from any country over which 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 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 radioactive material means radioactive material which has not been demonstrated to qualify as "special form radioactive material."

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

(1) *Excepted package* means a packaging together with its excepted radioactive materials as specified in §§ 173.421-173.423.

(2) *Industrial package* means a packaging together with its low specific activity (LSA) material or surface contaminated object (SCO) contents limited to $2A_1$ that meets the requirements of §§ 173.410 and 173.411. An industrial package is classified (see § 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)*.

(3) *Type A package* means a packaging together with its radioactive contents limited to A_1 or A_2 , as appropriate that 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.

(4) *Type B package* means a Type B packaging together with its radioactive contents that 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, together with its radioactive contents, that 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 radioactive material to the environment under the hypothetical accident conditions specified in 10 CFR part 71.

Packaging means, for 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	268.0
5 keV	228.0
20 keV	112.0
100 keV	32.0
500 keV	12.0
1 MeV	7.2
5 MeV	7.2
10 MeV	6.8

¹ Flux densities equivalent for energies between those listed above may be obtained by linear interpolation.

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 radioactive material in gaseous or non-dispersible solid form as a component part.

Radioactive contents means the radioactive material, together with any contaminated liquids or gases, within the package.

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

Special form radioactive material means 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, and constructed prior to July 1, 1985 and special form encapsulations designed in accordance with the requirements of § 173.403 in effect on June 30, 1989, and constructed prior to July 1, 1991, 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 radioactive material distributed on any of its surfaces. SCO must be in one of two groups with surface activity not exceeding the following limits:

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

(i) The non-fixed contamination on the accessible surface averaged over 300 cm² (or the area of the surface if less than 300 cm²) does not exceed 4 Bq/cm² (10⁻⁴ microcurie/cm²) for beta and gamma and low toxicity alpha emitters, or 0.4 Bq/cm² (10⁻⁵ microcurie/cm²) for alpha emitters;

(ii) The fixed contamination on the accessible surface averaged over 300 cm² (or the area of the surface if less than 300 cm²) does not exceed 4 × 10⁴ Bq/cm² (1.0 microcurie/cm²) for beta

and gamma and low toxicity alpha emitters, or 4 × 10⁵ Bq/cm² (0.1 microcurie/cm²) for alpha emitters; and

(iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm² (or the area of the surface if less than 300 cm²) does not exceed 4 × 10⁴ Bq/cm² (1 microcurie/cm²) for beta and gamma and low toxicity alpha emitters, or 4 × 10⁵ Bq/cm² (0.1 microcurie/cm²) for all other alpha emitters.

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

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

(ii) The fixed contamination on the surface averaged over 300 cm² (or the area of the surface if less than 300 cm²) does not exceed 8 × 10⁵ Bq/cm² (20 microcurie/cm²) for beta and gamma and low toxicity alpha emitters, or 8 × 10⁵ Bq/cm² (2 microcuries/cm²) for all other alpha emitters; and

(iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm² (or the area of the surface if less than 300 cm²) does not exceed 8 × 10⁵ Bq/cm² (20 microcuries/cm²) for beta and gamma and low toxicity alpha emitters, or 8 × 10⁵ Bq/cm² (2 microcuries/cm²) for all other alpha emitters.

Transport index means the dimensionless number (rounded up to the first decimal place) 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 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, for criticality control purposes, the number obtained by dividing 50 by the allowable number of

packages which may be transported together, whichever is larger.

Unilateral approval means approval of the 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 (0.20 millicuries) of fission products per gram of uranium-235.

Uranium—natural, depleted or enriched:

(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.

§ 173.404 U.S. competent authority.

The U.S. Competent Authority responsible for administering the requirements of Sections II and VII of the IAEA "Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6," and Subpart I is the U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Materials Transportation (OHMT), 400 Seventh Street, SW., Washington, DC 20590.

§ 173.405 General radiation protection principles.

Persons involved in the offering and accepting of packages containing radioactive materials for transportation shall maintain a radiation protection program in accordance with this section.

(a) The radiation exposure of transport workers must be in accordance with the recommendations specified in the Environmental Protection Agency's "Radiation Protection Guidance to Federal Agencies for Occupational Exposure (January 1987)."

(b) Radiation exposures from the handling, storage and transport of radioactive material must be kept as low as is reasonably achievable (ALARA). The term "as low as is reasonably achievable" means as low as is reasonably achievable taking into account the state of technology, the economics of improvements in relation to benefits to the public health and

safety, and other societal and socioeconomic considerations.

(c) Transport workers must be given appropriate training concerning the radiation hazards involved and the precautions to be observed.

(d) The nature and extent of the measures to be employed in controlling radiation exposures must be related to the magnitude and likelihood of the exposures. As a minimum, for individual occupationally-exposed workers:

(1) If the dose received is not likely to exceed 5 millisievert (500 millirem) per year, neither special work patterns nor detailed monitoring or assessment of radiation doses are required;

(2) If the dose received is likely to be between 5 mSv (500 mrem) and 15 mSv (1500 mrem) per year, periodic assessments of radiation exposure levels must be conducted;

(3) If the dose received is likely to be between 15 mSv (1500 mrem) and 50 mSv (5000 mrem) per year, individual radiation exposure monitoring programs and special health supervision are required.

(e) The radiation exposures to members of the general public must not exceed radiation levels that, if an individual were continuously present in the area, could result in exposures to that individual of:

- (1) 0.02 mSv (2 mrem) in any hour;
- (2) 1.0 mSv (100 mrem) in any week; or
- (3) 5.0 mSv (50 mrem) in any twelve-month period.

§ 173.410 General design requirements.

In addition to the requirements of § 173.24, each package used for the shipment of 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 device under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package 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 at the time of transport, and that is not a part of 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;

(g) The materials 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 operations; and

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

(j) 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 insolation;

(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/in²).

§ 173.411 Additional design requirements for industrial packages.

(a) An industrial package Type 1 (IP-1) must meet the general design requirements prescribed in § 173.410.

(b) In addition to meeting the requirements for an IP-1, an industrial package Type 2 (IP-2) when subjected to the tests specified in § 173.465(c) and § 173.465(d) or evaluated against these tests by any of the methods authorized by any of the methods authorized by § 173.461(a), must prevent:

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

(2) Significant increase in the radiation levels recorded or calculated

at the external surfaces for the condition before the test.

(c) In addition to meeting the requirements for an IP-1, an industrial package Type 3 (IP-3) must meet the requirements specified in § 173.412(a) through § 173.412(i).

§ 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 exclusive use closed transport vehicles, the cargo compartment, instead of the individual packages, may be sealed;

(b) 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 will be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.

(c) 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 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;

(d) 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;

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

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

(g) 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;

(h) Failure of any tie-down attachment on the packaging under both normal and accident conditions will not impair the ability of the package to meet other requirements of this subpart;

(i) 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) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test;

(j) 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 (i) 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 shall 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 components in the event that the primary inner components leak; and

(k) 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.

Each Type B(U) or Type B(M) package must be designed and constructed to meet the applicable requirements in 10 CFR part 71.

§ 173.414 Authorized industrial packages.

The following packages are authorized for shipment of low specific activity (LSA) material and surface contaminated objects (SCO) not exceeding $2A_1$:

(a) Any package that meets the requirements of § 173.411 and is used as prescribed in Table 8 of § 173.425.

(b) Specification IM 101 or IM 102 portable tanks (§§ 178.270, 178.271,

178.272 of this subchapter) being used as IP-2 or IP-3 provided that they:

(1) Satisfy the requirements for IP-2 or IP-3, respectively, specified in § 173.411;

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

(3) Are 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

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

(c) Freight containers being used as IP-2 or IP-3 provided that:

(1) They satisfy the requirements for IP-2 or IP-3, respectively, specified in § 173.411;

(2) They are designed to conform to the requirements of ISO 1496/1-1978, "Series 1 Freight Containers—Specifications and Testing—Part 1: General Cargo Containers";

(3) They are 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 1496/1-1978; and

(4) For international transportation, each freight container must have a safety approval plate in conformance with 49 CFR 451.21 through 451.25.

(d) Each shipper of an industrial package must maintain on file for at least one year after the latest shipment, and shall provide to DOT on request, a 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.

§ 173.415 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) U.S. Department of Transportation (DOT) Specification 7A (§ 178.350 of this subchapter) Type A general packaging. Each shipper 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, a 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 packages designed in accordance with the requirements of § 178.350 in

effect on June 30, 1983, is not authorized after July 1, 1992.

(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 pursuant to § 173.416.

(d) Any foreign-made packaging that bears the marking "Type A" and was used for the import of radioactive materials. Such packagings may be subsequently used for domestic and export shipments of radioactive materials provided the shipper 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(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. This packaging is authorized only for export and import shipments.

(c) DOT Specification 6M (§ 178.104 of this subchapter) metal packaging, only for solid or gaseous 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 (§ 178.194 of this subchapter), wooden protective jacket, when used with a single, snug-fitting inner DOT Specification 2R (§ 178.34 of this subchapter). For liquid contents, the inner packaging must conform to § 173.412 (i) and (j).

(e) For contents in special form only: DOT Specification 20WC (§ 178.194 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 (§ 178.195 of this subchapter), wooden protective overpack, with a single inner DOT Specification 2R (§ 178.34 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 (§ 178.103 of this subchapter), metal packaging, for materials prescribed in paragraph (b)(1) of this section.

(2) DOT Specification 6M (§ 178.104 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 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 radioactive materials, that also meets the applicable standards for fissile materials in the regulations of 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 DOT Specification 6J (§ 178.100 of this subchapter) or 17H (§ 178.118 of this subchapter) 55-gallon steel drum, 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 § 178.103-5(a) 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 (i) and (j) of this subpart.

(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 SPECIFICATION 6J OR 17H PACKAGES

U-235 per package (grams)	Maximum quantity of Minimum transport		Maximum number of packages per transport vehicle
	Index per package	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.....	(*)		(*)

* Transport index is limited by the external radiation levels.

** Maximum number is limited by the total transport index.

(7) Any metal cylinder that meets the performance 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:

TABLE 3.—ALLOWABLE CONTENT OF URANIUM HEXAFLUORIDE (UF₆) "HEELS" IN A SPECIFICATION 7A CYLINDER

Maximum cylinder diameter		Cylinder volume		Maximum Uranium-235 enrichment (weight percent)	Maximum "Heel" weight per cylinder			
Centimeters	Inches	Liters	Cubic Feet		UF ₆		Uranium-235	
					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	.019	0.04
30.5	12	68.0	2.419	5.0	0.454	1.0	.015	0.03
76.0	30	725.0	25.64	5.0	11.3	25.0	.383	0.84
122.0	48	3,084.0	108.9	4.5	22.7	50.0	.690	1.52
122.0	48	4,041.0	142.7	4.5	22.7	50.0	.690	1.52

¹ 10 ton.
² 14 ton.

(8) DOT Specification 20PF-1, 20PF-2, or 20PF-3 (§ 178.120 of this subchapter), or Specification 21PF-1, 21PF-1A, 21PF-1B, or 21PF-2 (§ 178.121 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.

(ii) DOT Specification 21PF-1 overpacks in use or under construction before April 1, 1989, must be modified to

DOT Specification 21PF-1A before April 1, 1991. Use of unmodified DOT 21PF-1 overpacks is prohibited after March 31, 1991. All new construction to DOT Specification 21PF-1 beginning after March 31, 1989, must meet DOT Specification 21PF-1B.

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

(b) Fissile radioactive materials with radioactive content exceeding A₁ or A₂ must be packaged in one of the following packagings:

(1) DOT Specification 6L (§ 178.103 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. Radioactive materials in normal form must be packaged in one or more tightly sealed metal or polyethylene bottles within a DOT Specification 2R (§ 178.34 of this subchapter) containment vessel. Authorized contents are limited in accordance with Table 4:

TABLE 4.—AUTHORIZED CONTENTS IN KILOGRAMS (KG) AND CONDITIONS FOR SPECIFICATION 6L PACKAGES

Uranium-235		Plutonium ¹		Fissile transport index	Maximum number of packages per transport vehicle
H/X < 3 ²	3 H/X < 10	H/X < 10	10 H/X < 20		
14	3.6	2.5	2.4	1.3 1.8	80 50

¹ Plutonium solutions are not authorized.

² H/X is the ratio of hydrogen to fissile atoms in the inner containment with all sources of hydrogen in the containment considered.

³ Volume not to exceed 3.6 liters.

(2) DOT Specification 6M (§ 178.104 of this subchapter); metal packaging. These packages may contain only solid radioactive materials that will not decompose at temperatures up to 121 °C (250 °F). Radioactive decay heat output may not exceed 10 watts. 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 (§ 178.34 of this subchapter) containment vessel.

(i) Packages are limited to the following amounts of fissile 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 must 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 are given in Table 5. The minimum transport index to be assigned and 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 need be considered. For a uranium-233 shipment, the maximum inside diameter of the inner containment vessel must 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 § 178.104-3(b) of this subchapter to the 12.1 centimeter (4.75 inch) limit.

TABLE 5.—AUTHORIZED CONTENTS FOR SPECIFICATION 6M PACKAGES¹

Uranium-233 ⁵			Uranium-235 ^{4,7}			Plutonium ^{2,3,6}			Minimum transport index	Maximum no. of pkgs. per transport vehicle
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		
3.6	4.4	2.9	7.2	7.6	5.3	3.1	4.1	3.4	0.1	1,250
4.2	5.2	3.5	8.7	9.6	6.4	3.4	4.5	4.1	0.2	625
5.2	6.6	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 watt decay heat limitation.
⁴ For a mixture of uranium-235 and plutonium an equal amount of uranium-235 may be substituted by any portion of plutonium authorized.
⁵ Maximum inside diameter of Specification 2R containment vessel not to exceed 12.1 centimeters (4.75 inch) (see par. (b)(2)(ii) of this section).
⁶ Granulated or powdered metal with any particle less than 6.4 millimeter (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.

(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(U) or B(M) packaging that meets the applicable requirements for fissile radioactive materials in Section V of the IAEA "Regulations for the Safe Transport of Radioactive Materials,

Safety Series No. 8" 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 and 20PF-2 (§ 178.120 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.

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

TABLE 6.—AUTHORIZED QUANTITIES OF URANIUM HEXAFLUORIDE (UF₆)

Protective overpack specification number	Maximum inner cylinder diameter		Maximum weight of UF ₆ contents		Maximum ²³⁵ U enrichment (Weight/percent)	Minimum transport index
	Centimeters	Inches	Kilograms	Pounds		
20PF-1.....	12.7	5	25	55	100.0	0.1
20PF-2.....	20.3	8	116	225	12.5	0.4
20PF-3.....	30.5	12	209	460	5.0	1.1
21PF-1 ^{1,2,3}	76.0	30	2,250	4,950	5.0	5.0
	76.0	30	2,282	5,020	5.0	5.0
21PF-2 ¹	76.0	30	2,282	5,020	5.0	5.0
	76.0	30	2,250	4,950	5.0	5.0

¹ For 76 cm (30 in) cylinders, the maximum H/U atomic ratio is 0.098.
² Model 30A inner cylinder (Reference ORO-651).
³ Model 30B inner cylinder (Reference ORO-651).
⁴ 21PF-1 series includes the 21PF-1, 21PF-1A, and 21PF-1B. Allowable quantities are identical for all three overpacks. See the limitations on usage in paragraph (b)(5) of this section.

§ 173.418 Authorized packages—pyrophoric radioactive materials.

(a) Packages containing pyrophoric radioactive materials, as referenced in § 172.101 of this subchapter, may be transported in quantities not exceeding A₂ per package only in DOT Specification 7A packages provided that they are constructed of materials that will not react with, nor be decomposed by, the contents. Contents of the package must be:

(1) Packed as solid, nonfissile form unless excepted by § 172.453;

(2) Sealed in corrosion resistant receptacles with positive closures;

friction or slip-fit covers or stoppers are not authorized;

(3) Freed of water and contaminants that would increase the reactivity of the material; and

(4) Inerted to prevent self-ignition during transport by either.

(i) 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

(ii) Filling the innermost receptacle with an appropriate inert gas or liquid.

§ 173.419 Authorized packages—oxidizing radioactive materials.

(a) Packages containing oxidizing radioactive materials, as referenced in § 172.101 of this subchapter, may be transported in quantities not exceeding A₂ per package only in a DOT Specification 7A package provided that:

(1) The contents are:

(i) Packed in inside packagings of glass, metal or compatible plastic; and
 (ii) Cushioned with a material that will not react with the contents;

(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; and

(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 or low specific activity, 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 (1967, 1982 or 1971 edition) 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, OIM, 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.) must not exceed 61% of the certified volumetric capacity of the packaging. The volume of solid depleted uranium hexafluoride at 20 °C (68 °F.) must 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 of uranium hexafluoride must be periodically inspected, tested, marked and otherwise

conform with the American National Standard N14.1-1987.

(c) Each repair to a packaging for uranium hexafluoride must be performed in accordance with American National Standard N14.1-1987.

§ 173.421 Excepted packages for limited quantities of radioactive materials.

Packages that are used to transport radioactive materials whose activity per package does not exceed the limits specified in § 173.423 are excepted from the specification packaging, shipping paper and certification, marking, and labeling requirements of this subchapter and requirements of this subpart if:

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

(b) The radiation level at any point on the external surface of the package does not exceed 0.005 mSv/hour (0.5 mrem/hour);

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

(d) The outside of the inner packaging or, if there is no inner packaging, the outside of the packaging itself bears the marking "Radioactive";

(e) Except as provided in § 173.424, the package does not contain more than 15 grams of uranium-235; and

(f) The material is otherwise prepared for shipment as specified in accordance with § 173.421-1.

§ 173.421-1 Additional requirements for excepted packages containing radioactive materials.

(a) Excepted packages prepared for shipment under the provisions of § 173.421, § 173.422, § 173.424, or § 173.427 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 the statement "This package conforms to the conditions and limitations specified in 49 CFR § 173.421 for radioactive material, excepted package-limited quantity of material, UN2910; 49 CFR § 173.422 for radioactive material, excepted package—instruments or articles, UN2910; 49 CFR § 173.424 for radioactive material, excepted package—articles manufactured from natural or depleted uranium or natural thorium, UN2910; or 49 CFR § 173.427 for radioactive material, excepted package—empty packaging, UN2910," as appropriate.

(b) An excepted package prepared for shipment under the provisions of

§ 173.421, § 173.422, § 173.424, § 173.427 or § 173.421-2 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; or

(2) Sections 171.15, 171.16, 175.45, and 175.700(b) of this subchapter pertaining to the reporting of incidents and decontamination when transported by aircraft. After May 2, 1991, it is also necessary to comply with §§ 173.448(f) and 175.700(c) of this subchapter when transported by aircraft.

§ 173.421-2 Requirements for multiple hazard limited quantity radioactive materials.

(a) Except as provided in paragraph (b) of this section or in § 173.4 of this subchapter, when a limited quantity radioactive material meets the definition of another hazard class, it must be:

(1) Classed for the additional hazard;

(2) Packaged to conform with requirements specified in § 173.421 (a) through (e) or § 173.422 (a) through (g), as appropriate; and

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

(b) When a limited quantity radioactive material meets the definition of an ORM-A, B, or C, or is a combustible liquid in a packaging having a rated capacity of 110 gallons or less, it must be:

(1) Classed radioactive material if:

(i) The material is not a hazardous waste or hazardous substance; and

(ii) The material is offered for transportation in a mode to which requirements of this subchapter pertaining to the specific material and hazard class do not apply;

(2) Classed combustible liquid or ORM-A, B, or C, as appropriate, if:

(i) The material is a hazardous waste or hazardous substance; or

(ii) The material is offered for transportation in a mode to which requirements of this subchapter pertaining to the specific material and hazard class do apply;

(3) Packaged to conform with requirements specified in § 173.421 (a) through (e) or § 173.422 (a) through (g), as appropriate; and

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

(c) A limited quantity radioactive material which is classed other than

TABLE 5.—AUTHORIZED CONTENTS FOR SPECIFICATION 6M PACKAGES ¹

Uranium-233 ²			Uranium-235 ^{3, 4, 7}			Plutonium ^{2, 3, 4}			Minimum transport index	Maximum no. of pkgs. per transport vehicle
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		
3.6	4.4	2.9	7.2	7.6	5.3	3.1	4.1	3.4	0.1	1,250
⁵ 4.2	5.2	3.5	8.7	8.6	6.4	3.4	4.5	4.1	0.2	
⁶ 5.2	6.8	4.5	11.2	13.9	8.3	4.2		4.5	0.5	
			13.5	18.0	10.1	4.5			1.0	
				26.0	16.1				5.0	
				32.0	19.5				10.0	

¹ Quantity in kilograms.
² Minimum percentage of plutonium-240 is 5 weight percent.
³ 4.5 kilogram limitation of plutonium due to watt decay heat limitation.
⁴ For a mixture of uranium-235 and plutonium an equal amount of uranium-235 may be substituted by any portion of plutonium authorized.
⁵ Maximum inside diameter of Specification 2F containment vessel not to exceed 12.1 centimeters (4.75 inch) (see par. (b)(2)(ii) of this section).
⁶ Granulated or powdered metal with any particle less than 6.4 millimeter (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.

(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(U) or B(M) packaging that meets the applicable requirements for fissile 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 and 20PF-2 (§ 178.120 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.

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

TABLE 6.—AUTHORIZED QUANTITIES OF URANIUM HEXAFLUORIDE (UF₆)

Protective overpack specification number	Maximum inner cylinder diameter		Maximum weight of UF ₆ contents		Maximum ²³⁵ U enrichment (Weight/percent)	Minimum transport index
	Centimeters	Inches	Kilograms	Pounds		
20PF-1	12.7	5	25	55	100.0	0.1
20PF-2	20.3	8	116	225	12.5	0.4
20PF-3	30.5	12	209	460	5.0	1.1
21PF-1 ^{1, 2}	76.0	30	2,250	4,950	5.0	5.0
21PF-2 ¹	76.0	30	2,282	5,020	5.0	5.0
	76.0	30	2,282	5,020	5.0	5.0
	76.0	30	2,250	4,950	5.0	5.0

¹ For 76 cm (30 in) cylinders, the maximum H/U atomic ratio is 0.086.
² Model 30A inner cylinder (Reference ORO-651).
³ Model 30B inner cylinder (Reference ORO-651).
⁴ 21PF-1 series includes the 21PF-1, 21PF-1A, and 21PF-1B. Allowable quantities are identical for all three overpacks. See the limitations on usage in paragraph (b)(5) of this section.

§ 173.418 Authorized packages—pyrophoric radioactive materials.

(a) Packages containing pyrophoric radioactive materials, as referenced in § 172.101 of this subchapter, may be transported in quantities not exceeding A₂ per package only in DOT Specification 7A packages provided that they are constructed of materials that will not react with, nor be decomposed by, the contents. Contents of the package must be:

(1) Packed as solid, nonfissile form unless excepted by § 172.453;

(2) Sealed in corrosion resistant receptacles with positive closures;

friction or slip-fit covers or stoppers are not authorized;

(3) Freed of water and contaminants that would increase the reactivity of the material; and

(4) Inerted to prevent self-ignition during transport by either.

(i) 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

(ii) Filling the innermost receptacle with an appropriate inert gas or liquid.

§ 173.419 Authorized packages—oxidizing radioactive materials.

(a) Packages containing oxidizing radioactive materials, as referenced in § 172.101 of this subchapter, may be transported in quantities not exceeding A₂ per package only in a DOT Specification 7A package provided that:

(1) The contents are:

(i) Packed in inside packagings of glass, metal or compatible plastic; and
 (ii) Cushioned with a material that will not react with the contents;

(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; and

(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 or low specific activity, 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 (1987, 1982 or 1971 edition) 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	7.83 (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.) must not exceed 81% of the certified volumetric capacity of the packaging. The volume of solid depleted uranium hexafluoride at 20 °C (68 °F.) must 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 of uranium hexafluoride must be periodically inspected, tested, marked and otherwise

conform with the American National Standard N14.1-1987.

(c) Each repair to a packaging for uranium hexafluoride must be performed in accordance with American National Standard N14.1-1987.

§ 173.421 Excepted packages for limited quantities of radioactive materials.

Packages that are used to transport radioactive materials whose activity per package does not exceed the limits specified in § 173.423 are excepted from the specification packaging, shipping paper and certification, marking, and labeling requirements of this subchapter and requirements of this subpart if:

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

(b) The radiation level at any point on the external surface of the package does not exceed 0.005 mSv/hour (0.5 mrem/hour);

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

(d) The outside of the inner packaging or, if there is no inner packaging, the outside of the packaging itself bears the marking "Radioactive";

(e) Except as provided in § 173.424, the package does not contain more than 15 grams of uranium-235; and

(f) The material is otherwise prepared for shipment as specified in accordance with § 173.421-1.

§ 173.421-1 Additional requirements for excepted packages containing radioactive materials.

(a) Excepted packages prepared for shipment under the provisions of § 173.421, § 173.422, § 173.424, or § 173.427 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 the statement "This package conforms to the conditions and limitations specified in 49 CFR § 173.421 for radioactive material, excepted package-limited quantity of material, UN2910; 49 CFR § 173.422 for radioactive material, excepted package—instruments or articles, UN2910; 49 CFR § 173.424 for radioactive material, excepted package—articles manufactured from natural or depleted uranium or natural thorium, UN2910; or 49 CFR § 173.427 for radioactive material, excepted package—empty packaging, UN2910," as appropriate.

(b) An excepted package prepared for shipment under the provisions of

§ 173.421, § 173.422, § 173.424, § 173.427 or § 173.421-2 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; or

(2) Sections 171.15, 171.16, 175.45, and 175.700(b) of this subchapter pertaining to the reporting of incidents and decontamination when transported by aircraft. After May 2, 1991, it is also necessary to comply with §§ 173.448(f) and 175.700(c) of this subchapter when transported by aircraft.

§ 173.421-2 Requirements for multiple hazard limited quantity radioactive materials.

(a) Except as provided in paragraph (b) of this section or in § 173.4 of this subchapter, when a limited quantity radioactive material meets the definition of another hazard class, it must be:

(1) Classed for the additional hazard;

(2) Packaged to conform with requirements specified in § 173.421 (a) through (e) or § 173.422 (a) through (g), as appropriate; and

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

(b) When a limited quantity radioactive material meets the definition of an ORM-A, B, or C, or is a combustible liquid in a packaging having a rated capacity of 110 gallons or less, it must be:

(1) Classed radioactive material if:

(i) The material is not a hazardous waste or hazardous substance; and

(ii) The material is offered for transportation in a mode to which requirements of this subchapter pertaining to the specific material and hazard class do not apply;

(2) Classed combustible liquid or ORM-A, B, or C, as appropriate, if:

(i) The material is a hazardous waste or hazardous substance; or

(ii) The material is offered for transportation in a mode to which requirements of this subchapter pertaining to the specific material and hazard class do apply;

(3) Packaged to conform with requirements specified in § 173.421 (a) through (e) or § 173.422 (a) through (g), as appropriate; and

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

(c) A limited quantity radioactive material which is classed other than

radioactive material under provisions of paragraphs (a) or (b) of this section is excepted from requirements of § 173.421-1(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.

(d) After May 2, 1991, a limited quantity radioactive material classed other than radioactive material may not be offered for transportation aboard a passenger-carrying aircraft unless that material is intended for use in, or incident to, research, medical diagnosis or treatment.

§ 173.422 Excepted packages for radioactive instruments and articles.

Packages that contain radioactive instruments and articles are excepted from the specification packaging,

shipping paper and certification, marking and labeling requirements of this subchapter and requirements of this subpart, if:

- (a) The 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 § 173.423;
- (c) The total activity per package does not exceed the relevant limit listed in Table 7 in § 173.423;
- (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 § 173.424, the package does not contain more than 15 grams of uranium-235; and
 - (h) Each instrument or article (excepted radioluminescent time-pieces or devices) bears the marking "Radioactive".
- (i) The package is otherwise prepared for shipment as specified in § 173.421-1.

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

The limits applicable to instruments, articles, and limited quantities subject to exceptions under §§ 173.421 and 173.422 are shown in Table 7:

TABLE 7.—ACTIVITY LIMITS FOR LIMITED QUANTITIES, INSTRUMENTS, AND ARTICLES

Nature of contents	Instrument and articles		Materials package limits ¹
	Limits for each instrument or article ¹	Package limits ¹	
Solids:			
Special form	$10^{-3} A_1$	A_1	$10^{-3} A_1$
Other form	$10^{-3} A_2$	A_2	$10^{-3} A_2$
Liquids:	$10^{-3} A_2$	$10^{-3} A_2$	$10^{-3} A_2$
Gases:			
Tritium	$2 \times 10^{-3} A_1$	$2 \times 10^{-3} A_1$	$2 \times 10^{-3} A_1$
Special form	$10^{-3} A_1$	$10^{-3} A_1$	$10^{-3} A_1$
Other form	$10^{-3} A_2$	$10^{-3} A_2$	$10^{-3} A_2$

¹ For mixtures of radionuclides see § 173.443(b).

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

Packagings that contain manufactured articles in which the sole radioactive material content is natural or unirradiated depleted uranium, or natural thorium are excepted from the specification packaging, shipping paper and certification, and marking and labeling requirements of this subchapter and requirements of this subpart if:

- (a) The 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 (b), (c), and (d) are met; and
- (d) The article is otherwise prepared for shipment as specified in § 173.421-1.

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

In addition to other applicable requirements specified in this subchapter, low specific activity (LSA)

materials and surface contaminated objects (SCO) must be transported in accordance with the following conditions:

- (a) The quantity of LSA material or SCO in a single package or object or collection of objects must not exceed 2 A_2 ;
- (b) LSA material and SCO that are or contain fissile material must meet the applicable requirements of § 173.451;
- (c) Packages must meet the contamination control limits specified in § 173.443;
- (d) External radiation levels must comply with § 173.441; and
- (e) Except as specified in paragraph (g) of this section, LSA material and SCO must be packaged, as a minimum, in accordance with the package integrity levels specified in Table 8.
- (f) For packaged LSA material and SCO consigned as exclusive use:
 - (1) Shipments must be loaded by consignor and unloaded by consignee from the conveyance or freight container in which originally loaded.
 - (2) There must be no loose radioactive material in the conveyance.

(2) There must be no loose radioactive material in the conveyance.

(3) Shipment must be braced so as to prevent shifting of lading under conditions normally incident to transportation.

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

(g) Unpackaged (bulk) shipments of LSA-I and SCO-I materials must be transported only in exclusive use closed transport vehicles and must comply with the following conditions:

(1) Bulk liquids must be transported in the following:

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

(ii) Specification MC 310, MC 311, MC 312, or MC 331 (§ 178.343 or § 178.337 of this subchapter) cargo tanks. The requirements of § 173.412(j) do not apply to these cargo tanks. Bottom fittings and

valves are not authorized. Trailer-on-flat-car service is not authorized.

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

(3) Except for shipments of unconcentrated uranium or thorium ores, the transport vehicle must be placarded with the placards prescribed in Subpart F of Part 172 of this subchapter, as appropriate.

(4) There must be no leakage of radioactive materials from the vehicle.

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

(6) Transportation by aircraft is prohibited.

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

(i) Except for transportation by aircraft, LSA and SCO that conform with the provisions specified in 10 CFR 20.306 are excepted from all requirements of this subchapter pertaining to 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.

TABLE 8.—INDUSTRIAL PACKAGE INTEGRITY REQUIREMENTS FOR LSA MATERIAL AND SCO

Contents	Industrial package type ¹	
	Exclusive use shipment	Other than exclusive use shipment
LSA-I ² :		
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 ²	IP-1	IP-1
SCO-II.....	IP-2	IP-2

¹ See § 173.403

² Under the conditions specified in paragraph (g) of this Section, LSA-I material and SCO-I may be transported unpackageed.

TABLE 9.—CONVEYANCE ACTIVITY LIMITS FOR LSA MATERIAL AND SCO

Nature of material	Activity limit for conveyances ^a
LSA-I.....	No limit.
LSA-II and LSA-III: Non-flammable solids.	No limit.
LSA-II and LSA-III: Flammable solids, and all liquids and gases.	100 A ₂
SCO.....	100 A ₂

^a The concentration limit for tritium in liquid form, specified in § 173.435, does not apply.

§ 173.427 Empty radioactive materials packaging.

A packaging which previously contained 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 subpart, provided that:

(a) The packaging complies with the requirements of § 173.421 (b), (c), and (e) of this subpart;

(b) The packaging is in unimpaired condition and is securely closed so that there will be no leakage of 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 is affixed to the packaging; and

(e) The packaging is prepared for shipment as specified in § 173.421-1.

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

(a) A Type A package shall not contain a quantity of radioactive materials greater than A₁ for special form radioactive material or A₂ for normal form radioactive material as listed in § 173.435, or, for 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 or § 173.473.

§ 173.433 Requirements for determination of A₁ and A₂ values for radionuclides.

(a) Values of A₁ and A₂ for individual radionuclides that are the bases 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 A₁ and A₂ requires approval from the U.S. Competent Authority except that the values of A₁ and A₂ in Table 10 may be used without obtaining approval from the U.S. Competent Authority.

(c) In calculating A₁ and A₂ 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 A₁ or A₂ 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) For mixtures of radionuclides whose identities and respective activities are known, the following conditions will apply:

(1) For special form radioactive material:

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

(2) For other forms of radioactive materials:
(i) Either

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

where B(i) is the activity of radionuclide i and A₁ and A₂ values for radionuclide i, respectively; or
(ii)

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

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

(e) 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 A₁ or A₂ 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 A₁ or A₂ values for the alpha emitters or beta/gamma emitters, respectively.

TABLE 10.—GENERAL VALUES FOR A₁ and A₂

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 no relevant data are available	0.10	2.70	2×10 ⁻³	5.41×10 ⁻⁴

§ 173.434 Activity-Mass Relationships for Uranium and Natural Thorium.

Thorium and uranium enrichment ¹ (Wt. percent ²³⁵ U present)	Specific activity			
	TBq/gram	Grams/TBq	Ci/gram	Grams/Ci
0.45 (depleted)	1.9×10 ⁶	5.4×10 ⁷	5.0×10 ⁷	2.0×10 ⁶
0.72 (natural)	2.6×10 ⁶	3.8×10 ⁷	7.1×10 ⁷	1.4×10 ⁶
1.0	2.8×10 ⁶	3.6×10 ⁷	7.6×10 ⁷	1.3×10 ⁶
1.5	3.7×10 ⁶	2.7×10 ⁷	1.0×10 ⁸	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 ⁵	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 ⁸	4.7×10 ⁵	5.8×10 ⁵	1.7×10 ⁴
93.0	2.6×10 ⁸	3.9×10 ⁵	7.0×10 ⁵	1.4×10 ⁴
95.0	3.4×10 ⁸	3.0×10 ⁵	9.1×10 ⁵	1.1×10 ⁴
Natural Thorium	8.1×10 ⁸	1.2×10 ⁵	2.2×10 ⁷	4.6×10 ³

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-228.

§ 173.435 Table for A₁ and A₂ Values for Radionuclides.

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
²²⁷ Ac ¹	Actinium (89)	0.6	16.2	1×10 ⁻³	0.270	2.1×10 ³	5.8×10 ⁴
²²⁷ Ac		40	1080	2×10 ⁻³	5.4×10 ⁻⁴	2.7	7.2×10 ⁴
²²⁸ Ac		0.6	16.2	0.4	10.8	8.3×10 ⁴	2.2×10 ⁶
¹⁰⁴ Ag	Silver (47)	2	54	2	54	1.1×10 ³	3.0×10 ⁴
^{108m} Ag		0.6	16.2	0.6	16.2	9.7×10 ⁻³	2.9×10 ⁴
^{110m} Ag		0.4	10.8	0.4	10.8	1.8×10 ²	4.8×10 ³
¹¹¹ Ag		0.6	16.2	0.5	13.5	5.8×10 ²	1.6×10 ⁵
²⁶ Al	Aluminum (13)	0.4	10.8	0.4	10.8	7.0×10 ⁻⁴	1.9×10 ⁻²
²⁴¹ Am	Americium (95)	2	54	2×10 ⁻⁴	5.4×10 ⁻³	1.3×10 ⁻¹	3.4
²⁴³ Am		2	54	2×10 ⁻⁴	5.4×10 ⁻³	3.6×10 ⁻¹	9.7
²⁴⁴ Am		2	54	2×10 ⁻⁴	5.4×10 ⁻³	7.4×10 ⁻¹	2.0×10 ⁻¹
³⁷ Ar	Argon (18)	40	1080	40	1080	3.7×10 ²	1.0×10 ⁵
³⁹ Ar		20	541	20	540	1.3	3.4×10 ¹
⁴¹ Ar		0.6	16.2	0.6	16.2	1.6×10 ²	4.2×10 ⁷
⁴² Ar ¹		0.2	5.4	0.2	5.4	8.8	2.6×10 ²
⁷² As	Arsenic (33)	0.2	5.4	0.2	5.4	6.2×10 ⁴	1.7×10 ⁶
⁷³ As		40	1080	40	1080	8.2×10 ²	2.2×10 ⁴
⁷⁴ As		1	27	0.5	13.5	3.7×10 ³	9.9×10 ⁴
⁷⁵ As		0.2	5.4	0.2	5.4	5.8×10 ⁴	1.6×10 ⁶
⁷⁷ As		20	540	0.5	13.5	3.8×10 ⁴	1.0×10 ⁶
¹¹¹ At	Astatine (85)	30	810	2	54	7.6×10 ⁴	2.1×10 ⁶
¹⁹⁹ Au	Gold (79)	6	162	6	162	3.4×10 ⁴	9.2×10 ⁵
¹⁹⁸ Au		1	27	1	27.0	1.5×10 ⁴	4.1×10 ⁵
¹⁹⁹ Au		10	270	10	270	1.4×10 ³	3.7×10 ⁵
^{198m} Au		2	54	2	54	4.0×10 ³	1.1×10 ⁵
^{199m} Au		3	81	0.5	13.5	8.0×10 ²	2.4×10 ⁵
¹³¹ Ba	Barium (56)	10	270	0.9	24.3	7.7×10 ²	2.1×10 ⁵
^{132m} Ba		2	54	2	54.0	3.1×10 ³	8.4×10 ⁴
¹³² Ba		10	270	0.9	24.3	2.2×10 ⁴	6.1×10 ⁵
¹³³ Ba		3	81	3	81	8.4×10 ¹	2.6×10 ⁵
¹⁴⁰ Ba ¹		0.4	10.8	0.4	10.8	2.7×10 ³	7.3×10 ⁴
⁷ Be	Beryllium (4)	20	540	20	540	1.3×10 ⁴	3.5×10 ⁵
¹⁰ Be		20	540	0.5	13.5	8.4×10 ⁻³	2.2×10 ⁻²
²⁰⁹ Bi	Bismuth (83)	0.6	16.2	0.6	16.2	1.5×10 ²	4.2×10 ⁴
²⁰⁸ Bi		0.3	8.1	0.3	8.1	3.8×10 ²	1.0×10 ⁵

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
²⁰⁷ Bi		0.7	18.9	0.7	18.9	1.9	5.2×10 ¹
²¹⁰ Bi		0.3	8.1	3×10 ⁻³	0.81	2.1×10 ⁻³	5.7×10 ⁻⁴
²¹⁰ Pb		0.6	16.2	0.5	13.5	4.6×10 ³	1.2×10 ⁴
²¹² Bi		0.3	8.1	0.3	8.1	5.4×10 ⁵	1.5×10 ⁷
²⁴⁷ Bk	Berkelium (97)	2	54.0	2×10 ⁻³	5.4×10 ⁻³	3.6×10 ⁻²	1.0
²⁴⁹ Bk		40	1080	8×10 ⁻³	2.16	6.1×10 ¹	1.6×10 ²
⁷⁸ Br	Bromine (35)	0.3	8.1	0.3	8.1	3.4×10 ⁴	2.5×10 ⁶
⁷⁷ Br		3	81.0	3	81	2.6×10 ⁴	7.1×10 ⁶
⁸² Br		0.4	108	0.4	10.8	4.0×10 ⁴	1.1×10 ⁶
¹¹ C	Carbon (6)	1	270	0.5	13.5	3.1×10 ⁷	8.4×10 ⁸
¹⁴ C		40	1080	2	54.0	1.7×10 ⁻¹	4.5
⁴¹ Ca	Calcium (20)	40	1080	40	1080	3.1×10 ⁻³	8.5×10 ⁻³
⁴⁵ Ca		40	1080	0.9	24.3	6.6×10 ²	1.8×10 ⁴
⁴⁷ Ca		0.9	24.3	0.5	13.5	2.3×10 ⁴	6.1×10 ⁵
¹⁰⁹ Cd	Cadmium (48)	40	1080	1	27.0	9.6×10 ¹	2.6×10 ³
^{113m} Cd		20	540	8×10 ⁻³	2.43	8.3×10 ⁰	2.2×10 ²
^{114m} Cd		0.3	8.1	0.3	8.1	9.4×10 ³	2.6×10 ⁴
¹¹⁵ Cd		4	108	0.5	13.5	1.9×10 ⁴	5.1×10 ⁵
¹³⁸ Ce	Cerium (58)	6	162	6	162	2.5×10 ³	6.9×10 ³
¹⁴¹ Ce		10	270	0.5	13.5	1.1×10 ³	2.8×10 ⁴
¹⁴³ Ce		0.6	16.2	0.5	13.5	2.5×10 ⁴	6.6×10 ⁵
¹⁴⁴ Ce		0.2	5.4	0.21	5.4	1.2×10 ³	3.2×10 ³
²⁴⁴ Cf	Californium (98)	30	81	3×10 ⁻³	8.1×10 ⁻³	5.8×10 ¹	1.6×10 ³
²⁴⁹ Cf		2	54	2×10 ⁻⁴	5.4×10 ⁻⁴	1.5×10 ⁻¹	4.1
²⁵⁰ Cf		5	135	5×10 ⁻⁴	1.35×10 ⁻³	4.0	1.1×10 ²
²⁵¹ Cf		2	54.0	2×10 ⁻⁴	5.4×10 ⁻⁴	5.8×10 ⁻²	1.6
²⁵² Cf		0.1	2.70	1×10 ⁻⁵	2.70×10 ⁻⁵	2.0×10 ⁻²	5.4×10 ²
²⁵³ Cf		40	1080	6×10 ⁻³	1.62	1.1×10 ³	2.9×10 ⁴
²⁵⁴ Cf		3×10 ⁻³	8.1×10 ⁻³	8×10 ⁻⁴	1.62×10 ⁻³	3.1×10 ²	8.5×10 ³
³⁸ Cl	Chlorine (17)	20	540	0.5	13.5	1.2×10 ¹	3.3×10 ²
³⁹ Cl		0.2	5.4	0.2	5.4	4.9×10 ⁰	1.3×10 ⁰
²⁴⁶ Cm	Curium (96)	40	1080	2×10 ⁻³	0.54	7.5×10 ³	2.0×10 ⁴
²⁴⁷ Cm		2	54	0.9	24.3	6.1×10 ²	1.7×10 ³
²⁴⁸ Cm		40	1080	1×10 ⁻³	0.270	1.2×10 ³	3.3×10 ³
²⁴⁹ Cm		3	81	3×10 ⁻⁴	8.1×10 ⁻⁴	1.9	5.2×10 ¹
²⁵⁰ Cm		4	108	4×10 ⁻⁴	1.08×10 ⁻³	3.0	8.1×10 ¹
²⁵¹ Cm		2	54	2×10 ⁻⁴	5.4×10 ⁻⁴	6.4×10 ⁻²	1.7×10 ⁻¹
²⁵² Cm		2	54	2×10 ⁻⁴	5.4×10 ⁻⁴	1.3×10 ⁻¹	3.1×10 ⁻¹
²⁵³ Cm		2	54	2×10 ⁻⁴	5.4×10 ⁻⁴	3.4×10 ⁻¹	9.3×10 ⁻¹
²⁵⁴ Cm		2	54	2×10 ⁻⁴	5.4×10 ⁻⁴	1.6×10 ⁻¹	4.2×10 ⁻¹
⁵⁷ Co	Cobalt (27)	4×10 ⁻³	1.08	5×10 ⁻³	1.35×10 ⁻³	1.6×10 ⁻⁴	3.1×10 ⁻³
⁵⁸ Co		0.5	13.5	0.5	13.5	1.1×10 ³	3.0×10 ⁴
⁵⁹ Co		0.3	8.1	0.3	8.1	1.1×10 ³	3.0×10 ⁴
⁶⁰ Co		8	216	8	216	3.1×10 ³	8.4×10 ³
^{60m} Co	Cobalt (27)	40	1080	40	1080	2.2×10 ³	5.9×10 ³
⁶¹ Co		1	27.0	1	27.0	1.2×10 ³	3.2×10 ³
⁶² Co		0.4	10.8	0.4	10.8	4.2×10 ¹	1.1×10 ²
⁸¹ Cr	Chromium (24)	30	81	30	81	3.4×10 ³	9.2×10 ³
¹³⁷ Cs	Cesium (55)	4	108	4	108	2.8×10 ⁴	7.6×10 ⁵
^{137m} Cs		40	1080	40	1080	3.8×10 ³	1.0×10 ⁴
¹³⁸ Cs		1	27.0	1	27.0	5.7×10 ³	1.5×10 ⁴
¹³⁴ Cs		40	1080	9	243	3.0×10 ³	8.0×10 ³
¹³⁵ Cs		0.6	16.2	0.5	13.5	4.8×10 ¹	1.3×10 ²
¹³⁶ Cs		40	1080	0.9	24.3	4.3×10 ⁻¹	1.2×10 ⁻¹
¹³⁷ Cs(1)		0.5	13.5	0.5	13.5	2.7×10 ³	7.3×10 ³
⁶³ Cu	Copper (29)	2	54.0	0.5	13.5	3.2	8.7×10 ¹
⁶⁴ Cu		5	135	0.9	24.3	1.4×10 ¹	3.9×10 ²
⁶⁷ KCu		9	243	0.9	24.3	2.8×10 ¹	7.6×10 ²
¹⁵⁷ KDy	Dysprosium (66)	20	540	20	540	2.1×10 ²	5.7×10 ³
¹⁵⁸ Dy		0.6	16.2	0.5	13.5	3.0×10 ³	8.2×10 ³
¹⁵⁹ Dy(1)		0.3	8.1	0.3	8.1	6.9×10 ³	2.3×10 ⁴
¹⁶⁰ Dy		40	1080	0.9	24.3	3.1×10 ³	8.3×10 ³
¹⁷¹ Er	Erbium (68)	0.6	16.2	0.5	13.5	9.0×10 ¹	2.4×10 ²
¹⁴⁷ Eu	Europium (63)	2	54	2	54	1.4×10 ³	3.7×10 ³
¹⁵⁴ Eu		0.5	13.5	0.5	13.5	6.0×10 ³	1.6×10 ⁴
¹⁵⁰ Eu		20	540	20	540	3.5×10 ³	9.4×10 ³
¹⁵² Eu		0.7	18.9	0.7	18.9	6.1×10 ¹	1.7×10 ²
¹⁵³ Eu		0.6	16.2	0.5	13.5	8.2×10 ¹	2.2×10 ²
¹⁵⁴ Eu		0.9	24.3	0.9	24.3	6.5	1.8×10 ²
¹⁵⁵ Eu		0.8	21.6	0.5	13.5	9.3	2.6×10 ²
¹⁵⁶ Eu		20	540	2	54	1.8×10 ¹	4.9×10 ²
¹⁵⁷ Eu		0.6	16.2	0.5	13.5	2.0×10 ³	5.5×10 ³
¹⁶ F	Fluorine (9)	1	27.0	0.5	13.5	3.5×10 ⁴	9.5×10 ⁵
⁵⁵ Fe	Iron (26)	0.2	5.4	0.2	5.40	2.7×10 ³	7.3×10 ³
⁵⁹ Fe		40	1080	40	1080	8.8×10 ¹	2.4×10 ²
⁶⁰ Fe		0.8	21.6	0.8	21.6	1.8×10 ³	5.0×10 ³
⁶⁷ Ga	Gallium (31)	40	1080	0.2	5.4	7.4×10 ⁻¹	2.0×10 ⁻¹
⁶⁸ Ga		6	162	6	162	2.2×10 ¹	6.0×10 ¹
⁷² Ga		0.3	8.1	0.3	8.1	1.5×10 ⁴	4.0×10 ⁷
¹⁴⁸ Gd(1)	Gadolinium (64)	0.4	10.8	0.4	10.8	1.1×10 ³	3.1×10 ³
¹⁵⁰ Gd		0.4	10.8	0.4	10.8	6.9×10 ²	1.9×10 ³

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity			
						(TBq/g)	(Ci/g)		
¹⁴⁸ Gd	Germanium (32)	3	81	3 × 10 ⁻⁴	8.1 × 10 ⁻²	6.7	2.9 × 10 ¹		
¹⁵² Gd		10	270	5	135	1.3 × 10 ²	3.5 × 10 ²		
¹⁵⁶ Gd		4	108	0.5	13.5	3.9 × 10 ¹	1.1 × 10 ²		
⁶⁸ Ge(¹)		0.3	8.1	0.3	8.1	2.6 × 10 ²	7.1 × 10 ²		
⁷¹ Ge		40	1080	40	1080	5.8 × 10 ²	1.6 × 10 ³		
⁷³ Ge	0.3	8.1	0.3	8.1	1.3 × 10 ²	3.6 × 10 ²			
² H	Hydrogen (1)	(*)							
¹⁷³ Hf ⁰	Hafnium (72)	0.5	13.5	0.3	8.1	4.1 × 10 ¹	1.1 × 10 ²		
¹⁷⁵ Hf		3	81	3	81	3.9 × 10 ²	1.1 × 10 ³		
¹⁸¹ Hf		2	54	0.9	24.3	6.2 × 10 ²	1.7 × 10 ³		
¹⁸² Hf		4	108	3 × 10 ⁻²	0.81	8.1 × 10 ⁻²	2.2 × 10 ⁻²		
¹⁹⁴ KHg(²)		1	27.0	1	27.0	1.3 × 10 ⁻¹	3.5		
^{199m} Hg	Mercury (80)	5	135	5	135	1.5 × 10 ¹	4.0 × 10 ¹		
¹⁹⁷ Hg		10	270	0.9	24.3	2.5 × 10 ¹	6.7 × 10 ¹		
¹⁹⁸ Hg		10	270	10	270	9.2 × 10 ¹	2.5 × 10 ²		
²⁰¹ Hg		4	108	0.9	24.3	5.1 × 10 ¹	1.4 × 10 ²		
²⁰³ Hg		40	1080	40	1080	2.7	7.3 × 10 ¹		
^{168m} Ho	Holmium (67)	0.8	16.2	0.3	8.1	6.6 × 10	1.8		
¹⁶⁶ Ho		0.3	8.1	0.3	8.1	2.6 × 10 ¹	7.0 × 10 ¹		
¹²³ I		Iodine (53)	6	162	6	162	7.1 × 10 ¹	1.9 × 10 ²	
¹²⁴ I			0.9	24.3	0.9	24.3	9.3 × 10 ¹	2.5 × 10 ²	
¹²⁵ I			20	540	2	54	6.4 × 10 ¹	1.7 × 10 ²	
¹²⁶ I	2		54	0.9	24.3	2.9 × 10 ¹	8.0 × 10 ¹		
¹²⁹ I	(?)		(?)	(?)	(?)	6.5 × 10 ⁻¹	1.8 × 10 ¹		
¹²⁷ I	3	81	0.5	13.5	4.6 × 10 ¹	1.2 × 10 ²			
¹³² I	0.4	10.8	0.4	10.8	3.8 × 10 ¹	1.0 × 10 ²			
¹³³ I	0.6	16.2	0.5	13.5	4.2 × 10 ¹	1.1 × 10 ²			
¹³⁴ I	0.3	8.1	0.3	8.1	9.9 × 10 ¹	2.7 × 10 ²			
¹³⁵ I	0.6	16.2	0.5	13.5	1.3 × 10 ²	3.5 × 10 ²			
¹¹³ In	Indium (49)	2	54	2	54	1.5 × 10 ¹	4.2 × 10 ¹		
^{115m} In		4	108	4	108	6.2 × 10 ¹	1.7 × 10 ²		
^{114m} In(¹)		0.3	8.1	0.3	8.1	8.6 × 10 ¹	2.3 × 10 ²		
¹¹⁵ In		6	162	0.9	24.3	2.2 × 10 ²	6.1 × 10 ²		
¹⁸⁶ Ir		Iridium (77)	10	270	10	270	1.9 × 10 ²	5.2 × 10 ²	
¹⁹² Ir	0.7		18.9	0.7	18.9	2.3 × 10 ²	6.2 × 10 ²		
¹⁹⁴ Ir	1		27.0	0.5	13.5	3.4 × 10 ²	9.2 × 10 ²		
^{193m} Ir	10		270	10	270	2.4 × 10 ²	6.4 × 10 ²		
¹⁹⁴ Ir	0.2		5.4	0.2	5.4	3.1 × 10 ¹	8.4 × 10 ¹		
⁴⁰ K	Potassium (19)	0.8	16.2	0.6	16.2	2.4 × 10 ⁻¹	6.4 × 10 ⁻²		
⁴² K		0.2	5.4	0.2	5.4	2.2 × 10 ¹	6.0 × 10 ¹		
⁴³ K		1.0	27.0	0.5	13.5	1.2 × 10 ²	3.3 × 10 ²		
⁸¹ Kr		Krypton (36)	40	1080	40	1080	7.8 × 10 ⁻²	2.1 × 10 ⁻²	
^{80m} Kr			6	162	6	162	3.0 × 10 ¹	8.2 × 10 ¹	
⁸³ Kr	20		540	10	270	1.5 × 10 ¹	3.9 × 10 ¹		
⁸⁷ Kr	0.2		5.4	0.2	5.4	1.0 × 10 ¹	2.8 × 10 ¹		
¹³⁷ La	Lanthanum (57)		40	1080	2	54	1.6 × 10 ⁻²	4.4 × 10 ⁻³	
¹⁴⁰ La		0.4	10.8	0.4	10.8	2.1 × 10 ¹	5.6 × 10 ¹		
LSA		Low Specific Activity Material Definition (See § 173.409).							
¹⁷³ Lu		Lutetium (71)	0.5	13.5	0.5	13.5	4.2 × 10 ¹	1.1 × 10 ²	
¹⁷⁵ Lu			8	216	8	216	5.6 × 10 ¹	1.5 × 10 ²	
^{174m} Lu	20		540	8	216	2.0 × 10 ¹	5.3 × 10 ¹		
¹⁷⁶ Lu	8		216	4	108	2.3 × 10 ¹	6.2 × 10 ¹		
¹⁷⁷ Lu	30		810	0.9	24.3	4.1 × 10 ¹	1.1 × 10 ²		
MFP	Mixed Fission Products (use formula for mixture or Table 9).								
²⁴ Mg ¹	Magnesium (12)	0.2	5.4	0.2	5.4	2.0 × 10 ¹	5.4 × 10 ¹		
⁵⁴ Mn		Manganese (25)	0.3	8.1	0.3	8.1	1.6 × 10 ¹	4.4 × 10 ¹	
⁵⁵ Mn			(?)	(?)	(?)	(?)	6.8 × 10 ⁻²	1.8 × 10 ⁻²	
⁵⁶ Mn			1	27.0	1	27.0	2.9 × 10 ¹	7.7 × 10 ¹	
⁵⁹ Mn			0.2	5.4	0.2	5.4	8.0 × 10 ¹	2.2 × 10 ²	
⁹⁹ Mo	Molybdenum (42)		40	1080	7	189	4.1 × 10 ⁻²	1.1	
⁹⁰ Mo		0.6	16.2	0.5	13.5	1.8 × 10 ¹	4.8 × 10 ¹		
¹³ N		Nitrogen (7)	0.6	16.2	0.5	13.5	5.4 × 10 ¹	1.5 × 10 ²	
²³ Na			Sodium (11)	0.5	13.5	0.5	13.5	2.3 × 10 ¹	6.3 × 10 ¹
²⁴ Na				0.2	5.4	0.2	5.4	3.2 × 10 ¹	8.7 × 10 ¹
^{92m} Nb	Niobium (41)			0.7	18.9	0.7	18.9	5.2 × 10 ¹	1.4 × 10 ²
⁹³ Nb				40	1080	6	162	8.8	2.4 × 10 ²
⁹⁴ Nb		0.8		16.2	0.6	16.2	6.9 × 10 ⁻²	1.9 × 10 ⁻¹	
⁹⁵ Nb		1	27.0	1	27.0	1.5 × 10 ¹	3.9 × 10 ¹		
⁹⁷ Nb		0.6	16.2	0.5	13.5	9.9 × 10 ¹	2.7 × 10 ²		
¹⁴⁷ Nd	Neodymium (60)	4	108	0.5	13.5	3.0 × 10 ¹	8.1 × 10 ¹		
¹⁴⁹ Nd		0.6	16.2	0.5	13.5	4.5 × 10 ¹	1.2 × 10 ²		
⁵⁹ Ni		Nickel (28)	40	1080	40	1080	3.0 × 10 ⁻²	8.0 × 10 ⁻³	
⁶⁰ Ni			40	1080	30	810	2.1	5.7 × 10 ¹	
⁶⁴ Ni			0.3	8.1	0.3	8.1	7.0 × 10 ¹	1.9 × 10 ²	
²³⁵ Np	Neptunium (93)		40	1080	40	1080	5.2 × 10 ¹	1.4 × 10 ²	
²³⁶ Np			7	189	1 × 10 ⁻²	2.07 × 10 ⁻²	4.7 × 10 ⁻²	1.3 × 10 ⁻²	

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
²³⁷ Np		2	54	2×10 ⁻⁴	13.5	2.6×10 ⁻⁵	7.1×10 ⁻⁴
²³⁹ Np		6	162	0.5	13.5	8.6×10 ⁻⁵	2.3×10 ⁻³
¹⁸⁵ Os	Osmium (76)	1	27.0	1	27.0	2/9×10 ²	27.5×10 ²
^{191m} Os		40	1080	40	1080	4.6×10 ⁴	1.3×10 ⁶
¹⁹¹ Os		10	270	0.9	24.3	1.6×10 ³	4.4×10 ⁴
¹⁹² Os		0.6	16.2	0.5	13.5	2.0×10 ¹	5.3×10 ²
¹⁶⁴ Os ¹		0.2	5.4	0.2	5.4	1.1×10 ¹	3.1×10 ²
³² P	Phosphorus (15)	0.3	8.1	0.3	8.1	1.1×10 ⁴	2.9×10 ⁵
³² P		40	1080	0.9	24.3	5.8×10 ³	1.6×10 ⁵
²³³ Pu	Protactinium (91)	2	54	0.1	2.70	1.2×10 ³	3.3×10 ⁴
²³¹ Pa		0.6	16.2	6×10 ⁻³	1.62×10 ⁻²	1.7×10 ⁻²	4.7×10 ⁻³
²³³ Pa		5	135	0.9	24.3	7.7×10 ²	2.1×10 ⁴
²⁰⁷ Pb	Lead (82)	1	27.0	1	27.0	6.2×10 ⁴	1.7×10 ⁶
²⁰³ Pb		40	1080	2	54	1.2×10 ⁻⁴	3.4×10 ⁻³
²⁰³ Pb		3	81	3	81	1.1×10 ⁴	3.0×10 ⁵
²⁰³ Pb		(?)	(?)	(?)	(?)	4.5×10 ⁻⁶	1.2×10 ⁻⁴
²¹⁰ Pb ¹		0.6	16.2	9×10 ⁻³	0.243	2.8	7.6×10 ¹
²¹⁰ Pb ¹		0.3	8.1	0.3	8.1	5.1×10 ⁴	1.4×10 ⁶
¹⁰⁵ Pd	Palladium (46)	40	1080	40	1080	2.9×10 ²	7.5×10 ⁴
¹⁰⁷ Pd		(?)	(?)	(?)	(?)	1.9×10 ⁻³	5.1×10 ⁻⁴
¹⁰⁹ Pd		0.6	16.2	0.6	13.5	7.9×10 ⁴	2.1×10 ⁶
¹⁴³ Pm	Promethium (61)	3	81	3	81	1.3×10 ²	3.4×10 ³
¹⁴⁴ Pm		0.6	16.2	0.6	16.2	9.2×10 ¹	2.5×10 ²
¹⁴⁷ Pm		30	810	7	189	5.2	1.4×10 ²
¹⁴⁷ Pm		40	1080	0.9	24.3	3.4×10 ¹	9.3×10 ²
¹⁴⁸ Pm		0.5	13.5	0.5	13.5	7.9×10 ²	2.1×10 ⁴
¹⁴⁹ Pm		0.6	16.2	0.5	13.5	1.5×10 ⁴	4.0×10 ⁵
¹⁸¹ Pm		3	81	0.5	13.5	2.7×10 ⁴	7.3×10 ⁵
²⁰⁹ Po	Polonium (84)	40	1080	2×10 ⁻¹ —G510 ⁻²	0.54	2.2×10 ¹	5.9×10 ²
²⁰⁹ Po		40	1080	2×10 ⁻¹	0.54	6.2×10 ⁻¹	1.7×10 ¹
²¹⁰ Po		40	1080	2×10 ⁻²	0.54	1.7×10 ²	4.5×10 ³
¹⁴² Pr	Praseodymium (59)	0.2	5.4	0.2	5.4	4.3×10 ⁴	1.2×10 ⁶
¹⁴³ Pr		4	108	0.5	13.5	2.5×10 ³	6.7×10 ⁴
¹⁹⁵ Pt ¹	Platinum (78)	0.6	16.2	0.6	16.2	2.5×10 ³	6.8×10 ⁴
¹⁹⁵ Pt ¹		3	81	3	81	8.7×10 ²	2.4×10 ³
^{195m} Pt		40	1080	9	243	5.8×10 ³	1.6×10 ⁵
¹⁹⁵ Pt		40	1080	40	1080	1.4	3.7×10 ¹
^{195m} Pt		10	270	2	54	6.2×10 ²	1.7×10 ⁴
^{197m} Pt		10	270	0.9	24.3	3.7×10 ³	1.0×10 ⁷
¹⁹⁷ Pt		20	540	0.5	13.5	3.2×10 ⁴	8.7×10 ⁵
²³⁹ Pu	Plutonium (94)	7	189	7×10 ⁻⁴	1.89×10 ⁻³	2.0×10 ¹	5.3×10 ²
²³⁷ Pu		20	540	20	540	4.5×10 ²	1.2×10 ⁴
²³⁸ Pu		2	54	2×10 ⁻⁴	5.4×10 ⁻³	6.3×10 ⁻¹	1.7×10 ¹
²³⁹ Pu		2	54	2×10 ⁻⁴	5.4×10 ⁻³	2.3×10 ⁻²	6.2×10 ⁻³
²⁴⁰ Pu		2	54	2×10 ⁻⁴	5.4×10 ⁻³	8.4×10 ⁻³	2.3×10 ⁻³
²⁴¹ Pu		40	1080	1×10 ⁻³	0.270	3.8×10 ²	1.0×10 ³
²⁴² Pu		2	54	2×10 ⁻⁴	5.4×10 ⁻³	1.5×10 ⁻⁴	3.9×10 ⁻³
²⁴⁴ Pu ¹		0.3	8.1	2×10 ⁻⁴	5.4×10 ⁻³	6.7×10 ⁻³	1.9×10 ⁻³
²²⁶ Ra ¹	Radium (88)	0.6	16.2	3×10 ⁻³	0.81	1.9×10 ³	5.1×10 ⁴
²²⁶ Ra ¹		0.3	8.1	6×10 ⁻³	1.62	5.9×10 ²	1.6×10 ³
²²⁸ Ra ¹		0.6	16.2	2×10 ⁻³	0.54	1.4×10 ³	3.9×10 ⁴
²²⁶ Ra ¹		0.3	8.1	2×10 ⁻³	0.64	3.7×10 ⁻³	1.0
²²⁸ Ra ¹		0.6	16.2	4×10 ⁻³	1.08	1.0×10 ³	2.7×10 ³
⁸⁷ Rb	Rubidium (37)	2	54	0.9	24.3	3.1×10 ³	8.4×10 ⁴
⁸⁶ Rb		2	54	2	54	6.8×10 ²	1.8×10 ⁴
⁸⁴ Rb		1	27.0	0.9	24.3	1.8×10 ³	4.7×10 ⁴
⁸⁴ Rb		0.3	8.1	0.3	8.1	3.0×10 ³	8.1×10 ⁴
⁸⁷ Rb		(?)	(?)	(?)	(?)	3.2×10 ³	8.6×10 ⁻¹
Rb (natural)		(?)	(?)	(?)	(?)	6.7×10 ³	1.8×10 ⁴
¹⁸⁷ Re	Rhenium (75)	5	135	5	135	3.8×10 ³	1.0×10 ⁵
^{184m} Re		3	81	3	81	1.6×10 ²	4.3×10 ³
¹⁸⁴ Re		1	27.0	1	27.0	6.9×10 ²	1.9×10 ⁴
¹⁸⁶ Re		4	108	0.5	13.5	6.9×10 ²	1.9×10 ³
¹⁸⁷ Re		(?)	(?)	(?)	(?)	1.4×10 ⁻³	3.8×10 ⁻³
¹⁸⁸ Re		0.2	5.4	0.2	5.4	3.6×10 ⁴	9.8×10 ⁵
¹⁸⁸ Re		4	108	0.5	13.5	2.5×10 ⁴	6.8×10 ⁵
Re (natural)		(?)	(?)	(?)	(?)		
⁹⁹ Rh	Rhodium (45)	2	54	2	54	3.1×10 ³	8.2×10 ⁴
¹⁰¹ Rh		4	108	4	108	4.1×10 ³	1.1×10 ⁵
^{102m} Rh		2	54	0.9	24.3	2.3×10 ³	6.2×10 ⁴
¹⁰² Rh		0.5	13.5	0.5	13.5	4.5×10 ³	1.2×10 ⁵
^{103m} Rh		40	1080	40	1080	1.2×10 ⁶	3.3×10 ⁷
¹⁰³ Rh		10	270	0.9	24.3	3.1×10 ⁴	8.4×10 ⁵
²²² Rn ¹	Radon (86)	0.2	5.4	4×10 ⁻³	0.108	5.7×10 ²	1.5×10 ³
⁹⁷ Ru	Ruthenium (44)	4	108	4	108	1.7×10 ⁴	4.6×10 ⁵
¹⁰⁰ Ru		2	54	0.9	24.3	1.2×10 ³	3.2×10 ⁴
¹⁰¹ Ru		0.6	16.2	0.5	13.5	2.5×10 ³	6.7×10 ⁴
¹⁰² Ru		0.2	5.4	0.2	5.4	1.2×10 ²	3.3×10 ³
³² S	Sulfur (16)	40	1080	2	54	1.8×10 ³	4.3×10 ⁴
¹²² Sb	Antimony (51)	0.3	8.1	0.3	8.1	1.5×10 ⁴	4.0×10 ⁵

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity		
						(TBq/g)	(Ci/g)	
¹²⁴ Sb	Scandium (21)	0.6	16.2	0.5	13.5	6.5×10 ³	1.7×10 ⁴	
¹²⁵ Sb		2	54	0.9	24.3	3.9×10 ³	1.0×10 ⁴	
¹²⁶ Sb		0.4	10.8	0.4	10.8	3.1×10 ³	8.4×10 ³	
⁴⁴ Sc		0.5	13.5	0.5	13.5	6.7×10 ³	1.8×10 ⁴	
⁴⁶ Sc		0.5	13.5	0.5	13.5	1.3×10 ³	3.4×10 ⁴	
⁴¹ Sc		9	243	0.9	24.3	3.1×10 ³	8.3×10 ³	
^{46m} Sc		0.3	8.1	0.3	8.1	5.5×10 ³	1.5×10 ⁴	
SCO	Surface Contaminated Object Definition (See § 173.403)							
⁷⁸ Se	Selenium (34)	3	81	3	81	5.4×10 ³	1.5×10 ⁴	
⁷⁶ Se		40	1080	2	54	2.6×10 ⁻³	7.0×10 ⁻³	
³¹ Si	Silicon (14)	0.8	16.2	0.5	13.5	1.4×10 ³	3.9×10 ³	
³² Si		40	1080	0.2	5.4	3.9	1.1×10 ⁴	
¹⁴⁷ Sm	Samarium (62)	20	540	20	540	9.8×10 ³	2.6×10 ⁴	
^{147m} Sm		(²)	(²)	(²)	(²)	8.5×10 ⁻¹⁰	2.3×10 ⁻⁹	
¹⁴⁷ Sm		40	1080	4	108	9.7×10 ⁻¹	2.6×10 ¹	
¹⁵³ Sm		4	108	0.5	13.5	1.6×10 ⁴	4.4×10 ⁴	
^{153m} Sm		4	108	4	108	3.7×10 ³	1.0×10 ⁴	
¹¹⁷ Sn	Tin (50)	8	162	2	54	3.0×10 ³	8.2×10 ³	
^{119m} Sn		40	1080	40	108	1.4×10 ³	3.7×10 ³	
^{121m} Sn		40	1080	0.9	24.3	2.0×10 ³	5.4×10 ³	
¹²³ Sn		0.6	16.2	0.5	13.5	3.0×10 ³	8.2×10 ³	
¹¹⁵ Sn		0.2	5.4	0.2	5.4	4.0×10 ³	1.1×10 ⁴	
^{115m} Sn		0.3	8.1	0.3	8.1	1.1×10 ³	2.9×10 ³	
⁹² Sr		Strontium (38)	0.2	5.4	0.2	5.4	2.3×10 ³	6.2×10 ³
^{86m} Sr	5		135	5	135	1.2×10 ³	3.3×10 ³	
⁸⁵ Sr	2		54	2	54	6.8×10 ³	2.4×10 ⁴	
^{87m} Sr	3		81	3	81	4.8×10 ³	1.3×10 ⁴	
⁸⁹ Sr	0.6		16.2	0.5	13.5	1.1×10 ³	2.9×10 ³	
⁹⁰ Sr	0.2		5.4	0.1	2.7	5.1×10 ³	1.4×10 ⁴	
⁹¹ Sr	0.3		8.1	0.3	8.1	1.3×10 ³	3.6×10 ³	
⁹² Sr	0.2		5.4	0.2	5.4	4.7×10 ³	1.3×10 ⁴	
Tritium (1)	40		1080	40	1080	3.6×10 ³	9.7×10 ³	
¹⁸¹ Ta	Tantalum (73)		1	27.0	1	27	4.2×10 ³	1.1×10 ⁴
¹⁸² Ta		30	810	30	810	4.1×10 ³	1.1×10 ⁴	
¹⁶² Ta	Terbium (65)	0.8	21.6	0.5	13.5	2.3×10 ³	6.2×10 ³	
¹⁵⁷ Tb		40	1080	10	270	5.6×10 ⁻¹	1.5×10 ¹	
²⁰⁵ Tb		1	27.0	0.7	18.9	5.6×10 ⁻¹	1.5	
¹⁶⁰ Tb		0.9	24.3	0.5	13.5	4.2×10 ³	1.1×10 ⁴	
^{96m} Tc		Technetium (43)	2	54	2	54	8.3×10 ³	2.3×10 ⁴
^{96m} Tc	0.4		10.8	0.4	10.8	1.4×10 ³	3.8×10 ³	
⁹⁹ Tc	0.4		10.8	0.4	10.8	1.2×10 ³	3.2×10 ³	
^{97m} Tc	40		1080	40	1080	5.6×10 ³	1.5×10 ⁴	
⁹⁷ Tc	(²)		(²)	(²)	(²)	5.2×10 ⁻³	1.4×10 ⁻²	
⁹⁶ Tc	0.7		18.9	0.7	18.9	3.2×10 ³	8.7×10 ³	
^{99m} Tc	8		216	8	216	1.9×10 ³	5.3×10 ³	
⁹⁹ Tc	40		1080	0.9	24.3	6.3×10 ⁻⁴	1.7×10 ⁻³	
¹¹⁹ Te	Tellurium (52)		0.2	5.4	0.2	5.4	6.8×10 ³	1.8×10 ⁴
^{131m} Te			5	135	5	135	2.6×10 ³	7.0×10 ³
¹³¹ Te		2	54	2	54	2.4×10 ³	6.4×10 ³	
^{132m} Te		7	189	7	189	3.3×10 ³	8.9×10 ³	
¹³² Te		30	810	9	243	6.7×10 ³	1.8×10 ⁴	
^{127m} Te		20	540	0.5	13.5	3.5×10 ³	9.4×10 ³	
¹²⁷ Te		20	540	0.5	13.5	9.8×10 ³	2.6×10 ⁴	
^{120m} Te		0.6	16.2	0.5	13.5	1.1×10 ³	3.0×10 ³	
¹³⁰ Te		0.6	16.2	0.5	13.5	7.7×10 ³	2.1×10 ⁴	
^{131m} Te		0.7	18.9	0.5	13.5	3.0×10 ³	8.0×10 ³	
²³² Th	Thorium (90)	0.4	10.8	0.4	10.8	1.1×10 ³	3.0×10 ³	
²³² Th		9	243	1×10 ⁻³	0.270	1.1×10 ³	3.0×10 ³	
²³⁰ Th		0.3	8.1	4×10 ⁻⁴	1.08×10 ⁻³	3.0×10 ¹	8.2×10 ¹	
²³¹ Th		0.3	8.1	3×10 ⁻³	8.1×10 ⁻³	7.9×10 ⁻²	2.1×10 ⁻¹	
²³⁰ Th		2	54	2×10 ⁻⁴	5.4×10 ⁻³	7.6×10 ⁻⁴	2.1×10 ⁻³	
²³¹ Th		40	1080	0.9	24.3	2.0×10 ¹	5.3×10 ¹	
²³² Th		(²)	(²)	(²)	(²)	4.0×10 ⁻⁹	1.1×10 ⁻⁷	
²³⁴ Th		0.2	5.4	0.2	5.4	8.6×10 ³	2.3×10 ⁴	
Th (natural)		(²)	(²)	(²)	(²)	8.1×10 ³	2.2×10 ⁴	
⁴⁷ Ti		Titanium (22)	0.5	13.5	0.2	5.4	6.3	1.7×10 ³
⁵⁰ Ti	0.8		21.6	0.8	21.6	2.2×10 ⁴	6.0×10 ⁴	
²⁰¹ Tl	Thallium (81)	10	270	10	270	7.9×10 ³	2.1×10 ⁴	
²⁰³ Tl		2	54	2	54	2.0×10 ³	5.3×10 ³	
²⁰⁴ Tl		4	108	0.5	13.5	1.7×10 ³	4.6×10 ³	
¹⁸⁷ Tm		Thulium (69)	7	189	7	189	3.1×10 ³	8.5×10 ³
¹⁶³ Tm	0.8		21.6	0.8	21.6	3.1×10 ³	8.3×10 ³	
¹⁷⁰ Tm	4		108	0.5	13.5	2.2×10 ³	6.0×10 ³	
¹⁷¹ Tm	40		1080	10	270	4.0×10 ¹	1.1×10 ²	
²³⁰ U	Uranium (92)		40	1080	1×10 ⁻³	0.270	1.0×10 ¹	2.8×10 ¹
²³⁵ U		3	81	3×10 ⁻⁴	8.1×10 ⁻³	8.3×10 ⁻¹	2.2×10 ¹	
²³⁸ U		10	270	1×10 ⁻³	2.7×10 ⁻³	3.6×10 ⁻⁴	9.7×10 ⁻³	
²³⁴ U		10	270	1×10 ⁻³	2.70×10 ⁻³	2.3×10 ⁻⁴	6.2×10 ⁻³	

Symbol of radionuclide	Element and atomic number	A ₁ (TBq)	A ₁ (Ci)	A ₂ (TBq)	A ₂ (Ci)	Specific activity	
						(TBq/g)	(Ci/g)
²³⁵ U	Uranium (92)	(1)	(1)	(1)	(1)	8.0 × 10 ⁻⁴	2.2 × 10 ⁻⁴
²³⁸ U		10	270	1 × 10 ⁻³	2.7 × 10 ⁻³	2.4 × 10 ⁻⁴	6.5 × 10 ⁻⁵
^{234m} Pa		(2)	(2)	(2)	(2)	1.2 × 10 ⁻⁴	3.4 × 10 ⁻⁵
U (unlimited)		(4)	(4)	(4)	(4)	2.8 × 10 ⁻⁴	7.7 × 10 ⁻⁵
U (restricted to parent or less)		(2)	(2)	(2)	(2)	(2)	(2)
U (restricted more than 9 percent)	10	270	1 × 10 ⁻³	2.70 × 10 ⁻³	(2)	(2)	
U (restricted)	(2)	(2)	(2)	(2)	(2)	(2)	
⁵¹ V	Vanadium (23)	0.3	8.1	0.3	8.1	6.3 × 10 ⁻⁴	1.7 × 10 ⁻⁴
⁵² V	Tungsten (74)	40	1080	40	1080	3.0 × 10 ⁻³	8.1 × 10 ⁻⁴
¹⁸⁷ W		1	27.0	1	27.0	1.3 × 10 ⁻³	3.4 × 10 ⁻⁴
¹⁸³ W		30	810	30	810	2.2 × 10 ⁻³	6.0 × 10 ⁻⁴
¹⁸⁵ W		40	1080	0.9	24.3	3.5 × 10 ⁻³	9.4 × 10 ⁻⁴
¹⁸⁷ W		2	54	0.5	13.5	2.6 × 10 ⁻³	7.0 × 10 ⁻⁴
¹⁸⁸ W	0.2	5.4	0.2	5.4	3.7 × 10 ⁻³	1.0 × 10 ⁻³	
¹³⁶ Xe	Xenon (54)	0.2	5.4	0.2	5.4	4.8 × 10 ⁻⁴	1.3 × 10 ⁻⁴
¹³⁵ Xe		0.2	5.4	0.2	5.4	4.4 × 10 ⁻⁴	1.2 × 10 ⁻⁴
¹²⁷ Xe		4	108	4	108	1.0 × 10 ⁻³	2.8 × 10 ⁻⁴
¹³³ Xe		40	1080	40	1080	3.1 × 10 ⁻³	8.4 × 10 ⁻⁴
¹³⁵ Xe		20	540	20	540	6.9 × 10 ⁻³	1.9 × 10 ⁻³
¹³⁷ Xe	4	108	4	108	8.5 × 10 ⁻⁴	2.6 × 10 ⁻⁴	
⁸⁹ Y	Yttrium (39)	2	54	2	54	1.7 × 10 ⁻³	4.5 × 10 ⁻⁴
⁹⁰ Y		0.4	10.8	0.4	10.8	5.2 × 10 ⁻³	1.4 × 10 ⁻³
⁹¹ Y		0.2	5.4	0.2	5.4	2.0 × 10 ⁻³	5.4 × 10 ⁻⁴
^{90m} Y		2	54	2	54	1.5 × 10 ⁻³	4.2 × 10 ⁻⁴
^{91m} Y		0.3	8.1	0.3	8.1	9.1 × 10 ⁻³	2.5 × 10 ⁻³
⁹² Y	0.2	5.4	0.2	5.4	3.6 × 10 ⁻³	9.8 × 10 ⁻⁴	
⁹³ Y	0.2	5.4	0.2	5.4	1.2 × 10 ⁻³	3.3 × 10 ⁻⁴	
¹⁰² Yb	Ytterbium (70)	3	81	3	81	6.9 × 10 ⁻³	2.4 × 10 ⁻³
¹⁷⁵ Yb		30	810	0.9	24.3	6.6 × 10 ⁻³	1.8 × 10 ⁻³
⁶⁵ Zn	Zinc (30)	2	54	2	54	3.0 × 10 ⁻³	8.2 × 10 ⁻⁴
^{66m} Zn		2	54	0.5	13.5	1.2 × 10 ⁻³	3.3 × 10 ⁻⁴
⁶⁸ Zn	4	108	0.5	13.5	1.8 × 10 ⁻³	4.9 × 10 ⁻⁴	
⁸⁸ Zr	Zirconium (40)	3	81	3	81	6.6 × 10 ⁻³	1.8 × 10 ⁻³
⁸⁹ Zr		40	1080	0.2	5.4	9.3 × 10 ⁻³	2.5 × 10 ⁻³
⁹⁰ Zr		1	27.0	0.9	24.3	7.9 × 10 ⁻³	2.1 × 10 ⁻³
⁹¹ Zr	0.3	8.1	0.3	8.1	7.0 × 10 ⁻³	1.9 × 10 ⁻³	

1 A₁ and/or A₂ value limited by daughter product decay.
 2 Unlimited.
 3 See T = Tritium.
 4 A₁ and A₂ are unlimited for radiation control purposes only. For nuclear critically safety this material is subject to the control placed on fissile material.
 5 See § 173.434.

§ 173.441 Radiation level limitations.

(a) Except as provided in paragraph (b) of this section, each package of radioactive materials offered for transportation must be designed and prepared for shipment so that under conditions normally incident to transportation the radiation level does not exceed 2 mSv/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 only, and the radiation levels for such shipment must not exceed the following during transportation:

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

- (i) The shipment is made in a closed transport vehicle;
- (ii) The package is secured within the vehicle so that its position remains fixed during transportation; and

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

(2) 2 mSv/h (200 mrem/h) at any point on the outer 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; and

(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 in conformance with § 173.405(d)(3) of this subpart.

(c) For shipments made under the provisions of paragraph (b) of this section, the shipper 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.

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

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

§ 173.442 Thermal limitations.

A package of 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.

(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 must not exceed ten times the limits set forth in Table 11.

(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 must not exceed ten times the levels prescribed in paragraph (a) of this section. The levels at the beginning of transport must 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 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 must 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 public highway rail of 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.

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

§ 173.444 Labeling requirements.

Each package of radioactive materials, unless excepted by § 173.421, § 173.422, § 173.424, or § 173.427, 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 radioactive materials.

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

§ 173.448 General transportation requirements.

(a) Each shipment of 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 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 may offer for transportation 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 may offer for transportation aboard a passenger-carrying aircraft any 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 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 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 radioactive materials packages contained therein.

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

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

(B) Except for fissile 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 must not exceed 3.0 for passenger-carrying aircraft shipments, or 10.0 for cargo-aircraft only shipments.

§ 173.451 Fissile materials—general requirements.

(a) Except as provided in § 173.453, each package containing fissile 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. 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 to TI 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(b) of this subpart.

(a) For fissile material, controlled shipments the shipper or carrier, as appropriate, shall 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 conveyance assigned to the exclusive use of the shipper with a specific restriction for the exclusive use to be provided in the appropriate arrangements between shipper and carrier and with instructions to that effect issued with the shipping papers;

(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 radioactive material required to bear one of the

labels prescribed in § 172.403 of this subchapter. Specific arrangements must be made between the shipper and the carrier, with instructions to that effect issued with the shipping papers; or

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

§ 173.459 Mixing of fissile material packages.

(a) Mixing of fissile material packages with other types of 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;

(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 specimens representing LSA-III, special form radioactive material (solid radioactive material or capsules), or with prototypes or samples of the packaging in which case the contents of the specimen or packaging for the test must simulate as closely as practicable the expected range of physical properties of the radioactive contents and the specimen 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 argument, when the calculation procedures and parameters are generally agreed to be reliable and conservative.

(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(i) 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, compression 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 must 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.—FREE DROP DISTANCE FOR TESTING PACKAGES TO NORMAL CONDITIONS OF TRANSPORT

Packaging mass Kilograms (Pounds)	Free drop distance	
	Meters	(Feet)
Mass 5000 (11,000).....	1.2	(4)
6000 (11,000) Mass 10,000 (22,000).....	0.9	(3)
10,000 (22,000) Mass 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 subparagraph (1) of this paragraph must be preceded by a free drop from 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 shall 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 (1.3 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 must 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 radioactive material must meet the test requirement of paragraph (b) of this section. Each solid specimen to be tested must be representative of the actual solid LSA-III material that will be transported. 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 percent 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); and

(4) The total activity of the free volume of water must be measured following the 7 day immersion test and must not exceed 0.1 A₂.

§ 173.469 Tests for special form radioactive materials.

(a) Special form radioactive materials must meet the test requirements of paragraph (b) of this section. Each solid radioactive material or capsule specimen to be tested must be manufactured or fabricated so that it is representative of the actual solid material or capsule that will be transported with the proposed radioactive content duplicated closely as practicable. Any differences between

the material to be transported and the test material such as the use of non-radioactive contents must be taken into account in determining whether the test requirements have been met. In addition:

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

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

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

(4) After each test, leaktightness or indispersibility of the specimen must be determined by a method no less sensitive than the leaching assessment 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-l/s (1.3×10^{-4} atm-cm³/s) based on air at 25 °C (77 °F) and one atmosphere differential pressure for solid radioactive content, or 10^{-6} torr-l/s (1.3×10^{-6} atm-cm³/s) for liquid or gaseous radioactive content; and

(5) A specimen that comprises or simulates radioactive material contained in a sealed capsule need not be subjected to the leaktightness procedure specified in this section provided it is alternatively subjected to any of the tests prescribed in ISO/TR4826-1979(E), "Sealed radioactive sources Leak test methods."

(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 25 millimeters (1 inch) in diameter with the edges rounded off to a radius of 3 millimeters \pm 0.3 millimeters (.12 inch \pm 0.012 inch);

(iii) The lead must be hardness number 3.5 to 4.5 on the Vickers scale and thickness 25 millimeters (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; and

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

(3) *Bending test.* (i) This test applies only to long, slender sources with a length of 10 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); and

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

(4) *Heat test.* The specimen must be heated in air to a temperature of not less than 800 °C (1472 °F), held at the 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 of 6-8 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 \pm 5° (122 °F \pm 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 \pm 5° (122 °F \pm 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) and this paragraph, § 173.469(c)(1)(vi), must 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 \pm 5° (122 °F \pm 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 (i), (ii), and (iii) must be repeated; and
 - (vi) The activity determined in paragraph (c)(2)(iii) must not exceed 2 kilobecquerels (0.05 microcurie).
- (d) A specimen that comprises or simulates radioactive material contained in a sealed capsule need not be subjected to—

- (1) The impact test and the percussion test of this section provided that the specimen is alternatively subjected to the Class 4 impact test prescribed in ISO 2919-1980(e), "Sealed Radioactive Sources Classification;" 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 shipper 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 shall also comply with the following requirements:

- (a) The shipper 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 the first export shipment of the package, the shipper shall obtain a U.S. Competent Authority Certificate for that package design or if one has already been issued, the shipper shall register with the U.S. Competent Authority as a user of the certificate. Upon registration the shipper will be furnished with a copy of the certificate. The shipper 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 a copy has already been furnished;

- (e) Each request for a U.S. Competent Authority Certificate as required by the IAEA regulations must be submitted in writing to the address set forth in § 173.404 of this subpart. The request must be in triplicate and include copies of the applicable USNRC packaging approval, USNRC Quality Assurance Program approval 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; and

- (f) Import and export shipments may be made in accordance with § 171.12 of this subchapter.

§ 173.472 Requirements for exporting DOT Specification Type B and fissile packages.

- (a) Any shipper 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 shipper shall register with the U.S. Competent Authority as a user of the appropriate U.S. Competent Authority Certificate and the shipment must be made in accordance with the certificate;
- (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 the first export shipment of the package, the shipper shall obtain a U.S. Competent Authority Certificate for that package design or if one has already been issued, the shipper shall register with the U.S. Competent Authority as a user of the certificate. Upon registration the shipper will be furnished with a copy of the certificate. The shipper 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 a copy has already been furnished;
- (f) Each request for a U.S. Competent Authority Certificate as required by the IAEA regulations must be submitted in writing to the address set forth in § 173.404 of this subpart. The request must be submitted in triplicate and must

include a description of the quality assurance program required by §§ 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. 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; and

- (g) Import and export shipments may be made in accordance with § 171.12 of this subchapter.

§ 173.473 Requirements for foreign-made packages.

In addition to other applicable requirements of this subchapter, each shipper 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 the IAEA "Regulations for the Safe Transport of Radioactive Materials, Safety Series No. 6," shall also comply with the following requirements.

- (a) Prior to the first shipment of such a package of radioactive materials into or from the U.S., the shipper 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 address set forth in § 173.404 of this subpart. The request must be in triplicate, contain all the information required by Section VII of the IAEA regulations, 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 shipper 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 same competent authority identification marking indicated on the competent authority certificate and revalidation;

- (c) Each shipping paper for a shipment of 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; and

(e) Import and export shipments may be made in accordance with § 171.12 of this subchapter.

§ 173.474 Quality control for construction of packaging.

(a) Prior to the first use of any packaging for the shipment of radioactive material, the shipper shall determine that:

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

(2) 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 radioactive materials.

Before each shipment of any radioactive materials package, the shipper shall 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 radioactive materials.

(a) Each shipper of special form radioactive materials shall maintain on file for at least one year after the latest shipment, and provide to the RSPA 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 radioactive material from the United States, each shipper shall obtain a Competent Authority Certificate for the specific material. For special form material manufactured outside the United States, and 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 to the address set forth in § 173.404 of this subpart. 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 be in triplicate and 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) If appropriate, a detailed statement of the capsule design and dimensions, including complete engineering drawings 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 radioactive material complies with § 173.469; and

(4) 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 radioactive materials with an activity greater than $3 \times 10^4 A_1$, or $3 \times 10^3 A_2$, 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 the 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 173.427 or for Type A packagings designed for non-fissile 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 radioactive materials exceeding A_1 or A_2 , the shipper 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. The shipper is not required to await an acknowledgment from the competent authority prior to shipping the 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 shipper 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:

(1) Type B(U) packagings containing radioactive materials with an activity greater than $3 \times 10^3 A_1$, $3 \times 10^3 A_2$, 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 shipper 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 radioactive material or nuclide;

(4) A description of the physical and chemical form of the radioactive material; and

(5) The maximum activity of the radioactive material, except that for fissile material, the mass of fissile material may be used instead of activity.

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

PART 174—CARRIAGE BY RAIL

16. The authority citation for part 174 would change to read as follows:

Authority: 49 App. U.S.C. 1803, 1804, 1808; 49 CFR 1.53(e), 1.53, App. A to part 1.

17. Sections 174.700 and 174.715 would be amended to read as follows:

§ 174.700 Special handling requirements for radioactive materials.

(a) Each rail shipment of low specific activity materials or surface contaminated objects as defined in § 173.403 of this subchapter must be loaded so as to avoid spillage and scattering of loose material. Loading

restrictions are prescribed in § 173.425 of this subchapter.

(b) The number of packages of radioactive materials that may be transported by rail or stored at any single location is limited to that number which does not make a total transport index number (as defined in § 173.403 of this subchapter, and determined by adding together the transport index numbers on the labels of the individual packages) of more than 50. This provision does not apply to exclusive use shipments as described in §§ 173.403, 173.425, 173.441, and 173.457.

(c) Each package of radioactive material bearing RADIOACTIVE YELLOW-II or RADIOACTIVE YELLOW-III labels may not be placed closer than 0.9 meter (3 feet) to an area (or dividing partition between areas) which may be continuously occupied by any passenger, rail employee, or shipment of one or more animals, nor closer than 4.5 meters (15 feet) to any package containing undeveloped film (if so marked). If more than one package of radioactive materials is present, the distance must be computed from the table below on the basis of the total transport index number (determined by adding together the transport index numbers on the labels of the individual packages) of packages in the rail car or storage area:

Total transport index	Minimum separation distance to nearest undeveloped film		Minimum distance to area of persons, or minimum distance from dividing partition of a combination car	
	(m)	(ft)	(m)	(ft)
None.....	0	0	0	0
0.1 to 10.0.....	4.5	15	0.9	3
10.1 to 20.0.....	6.7	22	1.2	4
20.1 to 30.0.....	7.7	29	1.5	5
30.1 to 40.0.....	10	33	1.8	6
40.1 to 50.0.....	10.9	36	2.1	7

Note: The distance in the table must be measured from the nearest point on the nearest packages of radioactive materials.

(d) Each fissile material, controlled shipment must be transported in accordance with one of the methods prescribed in § 173.457 of this subchapter. The transport controls must be adequate to assure that no fissile material, controlled shipment is transported in the same transport vehicle with any other fissile radioactive material shipment. In loading and storage areas each fissile material, controlled shipment must be segregated by a distance of at least 6 meters (20 feet) from other packages required to bear one of the "radioactive" labels described in Part 172 of this subchapter.

(e) A person may not remain unnecessarily in, on or near a transport vehicle containing radioactive materials.

(f) In the case of packages shipped under the exclusive use provisions of § 173.441(b) for packages with external radiation levels in excess of 2 mSv per hour (200 mrem per hour) at the package surface—

(1) The transport vehicle must meet the requirements for a closed transport vehicle (§ 173.403 of this subchapter);

(2) Each package must be secured so that its position within the transport vehicle remains fixed under conditions normally incident to transportation; and

(3) The radiation level shall not exceed 0.02 mSv per hour (2 mrem per hour) in any normally occupied position in the transport vehicle or adjacent rail car.

§ 174.715 Cleanliness of transport vehicles after use.

(a) Each transport vehicle used for transporting radioactive materials as exclusive use, as defined in § 173.403 of this subchapter, must be surveyed with appropriate radiation detection instruments after each use. A transport vehicle may not be returned to service until the radiation dose rate at any accessible surface is 0.005 mSv per hour (0.5 mrem per hour) or less, and there is no significant removable radioactive surface contamination, as defined in § 173.443 of this subchapter.

(b) This section does not apply to any transport vehicle used solely for transporting radioactive materials if a survey of the interior surface shows that

the radiation dose rate does not exceed 0.1 mSv per hour (10 mrem per hour) at the interior surface or 0.02 mSv per hour (2 mrem per hour) at 1 meter (3.3 feet) from any interior surface. The transport vehicle must be stenciled with the words "FOR RADIOACTIVE MATERIALS USE ONLY" in lettering at least 0.076 meter (3 inches) high in a conspicuous place on both sides of the exterior of the transport vehicle, and it must be kept closed at all times other than during loading and unloading.

18. In § 174.750, paragraph (a) would be revised to read as follows:

§ 174.750 Incidents involving leakage.

(a) In addition to the incident reporting requirements of §§ 171.15 and 171.16 of this subchapter, the carrier shall also notify the shipper at the earliest practicable moment following any incident in which there has been breakage, spillage, or suspected radioactive contamination involving radioactive materials shipments. Transport vehicles, buildings, areas, or equipment in which radioactive materials have been spilled may not be again placed in service or routinely occupied until the radiation dose rate at every accessible surface is less than 0.005 mSv per hour (0.5 mrem per hour) and there is no significant removable radioactive surface contamination (see § 173.443 of this subchapter).

PART 175—CARRIAGE BY AIRCRAFT

19. The authority citation for part 175 would continue to read as follows:

Authority: 49 App. U.S.C. 1803, 1804, 1805, 1807, 1808; 49 App. U.S.C. 1472(h)(1); 49 CFR part 1.

20. In § 175.700, paragraph (b) would be revised to read as follows:

§ 175.700 Special limitations and requirements for radioactive materials.

(b) In addition to the reporting requirements of § 175.45, the carrier must also notify the shipper at the earliest practicable moment following any incident in which there has been breakage, spillage, or suspected radioactive contamination involving radioactive materials shipments. Aircraft in which radioactive materials have been spilled may not again be placed in service or routinely occupied until the radiation dose rate at every accessible surface is less than 0.005 mSv per hour (0.5 mrem per hour) and there is no significant removable radioactive surface contamination as determined in accordance with § 173.443 of this subchapter. When contamination is

present or suspected, the package and/or materials it has touched must be segregated as far as practicable from personnel contact until appropriate radiological advice or assistance is obtained. The Regional Office of the U.S. Department of Energy or appropriate State or local radiological authorities can provide advice or assistance, and should be notified in cases of obvious leakage, or if it appears likely that the inside container may have been damaged. For personnel safety, the carrier must take care to avoid possible inhalation, ingestion, or contact by any person with radioactive materials that may have leaked or spilled from its package. Any loose radioactive materials and associated packaging materials must be left in a segregated area pending disposal instructions from responsible radiological authorities.

21. In § 175.702, paragraphs (a) and (b)(2)(i), (b)(2)(ii) and (b)(2)(iii) would be revised to read as follows:

§ 175.702 Requirements for carriage of packages containing radioactive materials in a cargo aircraft only.

(a) As used in this section, the term "group of packages" means packages that are separated from each other in an aircraft by a distance of 6 meters (20 feet) or less.

(b) * * *

(2) * * *

(i) The separation distance between the surfaces of the radioactive materials packages and the surfaces bounding the space occupied by any person or animal is at least 9 meters (30 feet).

(ii) The transport index for any group of packages does not exceed 50.0; and

(iii) Each group of packages is separated from every other group in the aircraft by not less than 6 meters (20 feet), measured from the outer surface of each group; and

22. In § 175.703, the introductory text of paragraph (c) and paragraph (d) would be revised to read as follows:

§ 175.703 Other special requirements for the acceptance and carriage of packages containing radioactive materials.

(c) No person may carry in an aircraft any package containing fissile radioactive materials (as defined in § 173.455(a)(3) of this subchapter), except—

(d) No person may offer or accept for transportation, or transport, by air—
(1) Vented Type B(M) packages, packages which require external cooling

by an ancillary cooling system or packages subject to operational controls during transport; or

(2) Liquid pyrophoric radioactive materials.

PART 176—CARRIAGE BY VESSEL

23. The authority citation for part 176 would be revised to read as follows:

Authority: 49 App. U.S.C. 1803, 1804, 1805, 1808; 49 CFR 1.53, App. A to part 1.

24. In § 176.700, paragraph (a) would be removed and reserved and paragraph (c) would be revised to read as follows:

§ 176.700 General stowage requirements.

(a) [reserved]

(c) Each fissile material, controlled shipment must be stowed in a separate hold, compartment, or defined deck area and be separated by a distance of at least six meters (20 feet) from all other Radioactive Yellow II or Yellow III labeled packages.

25. Section 176.704 would be revised to read as follows:

§ 176.704 Requirements relating to transport indexes.

(a) The sum of the transport indexes for all packages of radioactive materials on board a vessel may not exceed the limits specified in Table III.

(b) The limitations specified in Table III do not apply to consignments of LSA-I materials if the packages are marked "RADIOACTIVE LSA-I" and no fissile radioactive materials are included in the shipment.

(c) For packages in freight containers, the radiation level must not exceed 2 mSv per hour (200 mrem per hour) at any point on the surface and 0.1 mSv per hour (10 mrem per hour) at two meters (6.6 feet) from the outside surface of the freight container.

(d) Each group of fissile packages must be separated from other radioactive material by a distance of at least six meters (20 feet) at all times.

(e) The limitations specified in paragraphs (a) through (d) of this section do not apply when the entire vessel is reserved or chartered for use by a single shipper under exclusive use conditions if:

(1) The number of fissile packages of radioactive materials aboard the vessel does not exceed the amount authorized in § 173.451 through § 173.459 of this subchapter; and

(2) The entire shipment operation is approved by the Director, Office of Hazardous Materials Transportation in advance.

TABLE III.—TI LIMITS FOR FREIGHT CONTAINERS AND CONVEYANCES

Type of freight container or conveyance	Limit on total sum of transport indexes in a single freight container or aboard a conveyance			
	Not under exclusive use		Under exclusive use	
	Non-fissile material	Fissile material	Non-fissile material	Fissile material *
Freight container—Small	50	50	N/A	N/A
Freight container—Large	50	50	No limit	100 ^b
Seagoing vessel ^c				
1. Hold, compartment or defined deck area:				
Packages, overpacks, small freight containers	50	50	No limit	100 ^b
Large freight containers	200 ^d	50	No limit	100 ^b
2. Total vessel:				
Packages, etc.	200 ^d	200 ^d	No limit ^e	200 ^a
Large freight containers	No limit ^d	No limit ^e	No limit	No limit ^d

* Provided that transport is direct from the consignor to the consignee without any intermediate in-transit storage, where the total TI exceeds 50.

^b In cases in which the total TI is greater than 50, the consignment must be so handled and stowed so that it is always separated from any other package, overpack, portable tank or freight container carrying radioactive material by at least 6 meters (20 feet).

^c For seagoing vessels the requirements given in 1 and 2 must both be fulfilled.

^d Provided that the packages, overpacks, portable tanks or freight containers, as applicable, are stowed so that the total sum of TIs in any individual group does not exceed 50, and that each group is handled and stowed so that the groups are separated from each other by at least 6 meters (20 feet).

^e Packages or overpacks carried in or on a transport vehicle which are offered for transport under the provisions of § 173.441(b), may be transported by vessel provided that they are not removed from the vehicle at anytime while on board the vessel.

26. In § 176.708, TABLE III would be redesignated as TABLE IV and paragraph (a) would be revised to read as follows:

§ 176.708 Segregation distance table.

(a) Table IV applies to the stowage of packages of radioactive materials on board a vessel with regard to transport index numbers which are shown on the labels of individual packages.

(b) Radioactive Yellow II or Yellow III labeled packages may not be stowed any closer to living accommodations, regularly occupied working spaces, spaces that may be continually occupied by any person (except those spaces exclusively reserved for couriers specifically authorized to accompany such packages), or undeveloped film than the distances specified to Table IV.

(c) Where only one consignment of a radioactive substance is to be loaded on board a vessel under exclusive use conditions, the appropriate segregation distance may be established by demonstrating that the direct measurement of the radiation level at regularly occupied working spaces and living quarters is less than 7.5 microSieverts per hour (0.75 mrem per hour).

(d) More than one consignment may be loaded on board a vessel with the appropriate segregation distance established by demonstrating that direct measurement of the radiation level at regularly occupied working spaces and living quarters is less than 7.5 microSieverts per hour (0.75 mrem per hour), provided that:

(1) The vessel has been chartered for the exclusive use of a competent person specialized in the carriage of radioactive material; and

(2) Stowage arrangements have been predetermined for the entire voyage, including any radioactive substances to be loaded at ports of call enroute.

(e) The radiation level shall be measured by a responsible person skilled in the use of monitoring instruments.

27. Section 176.715 is revised to read as follows:

§ 176.715 Contamination control.

Each hold, compartment, or deck area used for the transportation of low specific activity radioactive materials under exclusive use conditions shall be surveyed with appropriate radiation detection instruments after each use. Such holds, compartments, and deck areas may not be used again until the radiation dose rate at every accessible surface is less than 5 microSieverts per hour (0.5 mrem per hour), and the removable (non-fixed) radioactive surface contamination is not greater than the limits prescribed in § 173.443 of this subchapter.

PART 177—CARRIAGE BY PUBLIC HIGHWAY

28. The authority citation for part 177 would continue to read as follows:

Authority: 49 App. U.S.C. 1803, 1804, 1805, 49 CFR part 1.

§ 177.825 Amended

29. In paragraphs (b), (c) and (d) of § 177.825, the reference to "§ 173.403(1)" would be revised to read "§ 173.403".

30. Section 177.842 would be revised to read as follows:

§ 177.842 Radioactive material.

(a) The number of packages of radioactive materials in any transport vehicle or storage location must be limited so that the total transport index number does not exceed 50. The total transport index of group of packages and overpacks is determined by adding together the transport index number on the labels on the individual packages and overpacks in the group. This provision does not apply to exclusive use shipments described in §§ 173.441(b), 173.457, and 173.425 of this subchapter. (b) Packages of radioactive material bearing "radioactive yellow-II" or "radioactive yellow-III" labels must not be placed in a transport vehicle, storage location or in any other place closer than the distances shown in the following table to any area which may be continuously occupied by any passenger, employee, or animal, nor closer than the distances shown in the table to any package containing undeveloped film (if so marked), and must conform to the following conditions:

(1) If more than one of these packages is present, the distance shall be computed from the following table on the basis of the total transport index number determined by adding together the transport index number on the labels on the individual packages and overpacks in the vehicle or storeroom.

(2) Where more than one group of packages is present in any single storage location, a single group may not have a total transport index greater than 50. Each group of packages must be handled and stowed not closer than 6 meters (20 feet) (measured edge to edge) to any other group.

Total transport index	Minimum separation distance in meters (feet) to nearest undeveloped film in various times of transit					Minimum distance in meters (feet) to area of persons, or minimum distances in meters (feet) from dividing partition of cargo compartments
	Up to 2 hours	2-4 hours	4-8 hours	8-12 hours	Over 12 hours	
None.....	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
0.1 to 1.0.....	0.3 (1)	0.6 (2)	0.9 (3)	1.2 (4)	1.5 (5)	0.3 (1)
1.1 to 5.0.....	0.8 (3)	1.2 (4)	1.8 (6)	2.4 (8)	3.4 (11)	0.6 (2)
5.1 to 10.0.....	1.2 (4)	1.8 (6)	2.7 (9)	3.4 (11)	4.6 (15)	0.9 (3)
10.1 to 20.0.....	1.5 (5)	2.4 (8)	3.7 (12)	4.9 (16)	6.7 (22)	1.2 (4)
20.1 to 30.0.....	2.1 (7)	3.0 (10)	4.6 (15)	6.1 (20)	8.8 (29)	1.5 (5)
30.1 to 40.0.....	2.4 (8)	3.4 (11)	5.2 (17)	6.7 (22)	10.1 (33)	1.8 (6)
40.1 to 50.0.....	2.7 (9)	3.7 (12)	5.8 (19)	7.3 (24)	11.0 (36)	2.1 (7)

Note 1: The distance in the table must be measured from the nearest point on the nearest packages of radioactive materials.

(c) Shipments of low specific activity materials and surface contaminated objects, as defined in § 173.403 of this subchapter, must be loaded so as to avoid spillage and scattering of loose materials. Loading restrictions are set forth in § 173.425 of this subchapter.

(d) Packages must be so blocked and braced that they cannot change position during conditions normally incident to transportation.

(e) Persons should not remain unnecessarily in a vehicle containing radioactive materials.

(f) Each fissile material, controlled shipment (as defined in § 173.403 of this subchapter) must be transported in accordance with one of the methods prescribed in § 173.457 of this subchapter. The transport controls must be adequate to assure that no fissile material, controlled shipment is transported in the same transport vehicle with any other fissile radioactive material shipment. In loading and storage areas each fissile material, controlled shipment must be segregated by a distance of at least 6 meters (20 feet) from any other package required to bear one of the "Radioactive" labels described in § 172.403 of this subchapter.

(g) For shipments transported under exclusive use conditions the radiation dose rate must not exceed 0.02 mSv per hour (2 mrem per hour) in any position normally occupied in the motor vehicle. For shipments transported as exclusive use under the provisions of § 173.441(b) for packages with external radiation levels in excess of 2 mSv (200 mrem per hour) at the package surface, the motor vehicle must meet the requirements of a closed transport vehicle (§ 173.403 of

this subchapter). The total transport index for packages containing fissile material may not exceed 100.

31. In § 177.843, paragraphs (a) and (b) would be revised to read as follows:

§ 177.843 Contamination of vehicles.

(a) Each motor vehicle used for transporting radioactive materials under exclusive use conditions in accordance with § 173.425(c) or § 173.443(c) shall be surveyed with radiation detection instruments after each use. A vehicle may not be returned to service until the radiation dose rate at every accessible surface is 0.005 mSv per hour (0.5 mrem per hour) or less and the removable (non-fixed) radioactive surface contamination is not greater than the level prescribed in § 173.443(a).

(b) This section does not apply to any vehicle used solely for transporting radioactive material if a survey of the interior surface shows that the radiation dose rate does not exceed 0.1 mSv per hour (10 mrem per hour) at the interior surface or 0.02 mSv per hour (2 mrem per hour) at 1 meter (3.3 feet) from any interior surface. These vehicles must be stenciled with the words "For Radioactive Materials Use Only" in lettering at least 0.076 meter (3 inches) high in a conspicuous place, on both sides of the exterior of the vehicle. These vehicles must be kept closed at all times other than loading and unloading.

32. In § 177.861, paragraph (a) would be revised and Notes 1 and 2 would be removed to read as follows:

§ 177.861 Accidents: radioactive materials.

(a) In addition to the incident reporting requirements of §§ 171.15 and

171.16 of this subchapter, the carrier must also notify the shipper at the earliest practicable moment following any incident in which there has been breakage, spillage, or suspected radioactive contamination involving radioactive materials shipments. Vehicles, buildings, areas, or equipment in which radioactive materials have been spilled may not be again placed in service or routinely occupied until the radiation dose rate at every accessible surface is less than 0.005 mSv per hour (0.5 mrem per hour) and there is no significant removable radioactive surface contamination (see § 173.443 of this subchapter).

PART 178—SHIPPING CONTAINER SPECIFICATIONS

33. The authority citation for part 178 would continue to read as follows:

Authority: 49 App. U.S.C. 1803, 1804, 1805, 1806, 1808; 49 CFR part 1.

34. Section 178.350-2 would be revised to read as follows:

§ 178.350-2 Specific requirements.

Each packaging must be so designed and constructed that it meets the requirements of § 173.412 of this subchapter for Type A packaging.

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Alan L. Roberts,

Director, Office of Hazardous Materials Transportation.

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