

# Complete Documentation of Applicable Regulations and Regulatory Authority for Transportation

March 2020

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Harold E. Adkins, Jr.

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Prepared for  
the U.S. Department of Energy  
under Contract DE-AC05-76RL01830

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## Summary

This report fulfills the M4 milestone M4MR-20PN0303023, “Complete Documentation of Applicable Regulations and Regulatory Authority for Transportation.

Microreactors are very small nuclear reactors with a power output of 20MWe or less and are designed to be factory-built, modular in nature, and highly portable. The objective of this report is to identify and document applicable regulations, the appropriate regulatory authority, and the associated framework for microreactor transport.

Sections 2 and 3 of this report summarize U.S. Department of Transportation (DOT) and NRC regulations related to the transportation of Class 7 (radioactive) materials. These sections concentrate on the transport of fissile material packages and Type B packages, which would be most applicable to the transport of a microreactor before and after irradiation. Section 4 summarizes DOE hazardous and radioactive material transportation regulations. Section 5 summarizes U.S. Coast Guard regulations related to the transport of radioactive material. Section 6 discusses state requirements for the permitting of oversize and/or overweight truck shipments. Section 7 presents detailed schedules of requirements for transporting fissile material packages and Type B packages based on NRC and DOT regulations. The schedules are presented in a two-column format, the right column is the regulatory requirement and the left column is the citation of the regulation in which the requirement is found.

## Acknowledgments

Use Body Text for paragraphs in this section. PNNL reports use <http://www.chicagomanualofstyle.org/home.html> for document style. Right-click and choose open hyperlink to view the style guide.

## Acronyms and Abbreviations

AEA	Atomic Energy Act
CFR	Code of Federal Regulations
CO	Certifying Official
CoC	Certificate of Compliance
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE-NE	U.S. Department of Energy Office of Nuclear Energy
DOT	U.S. Department of Transportation
FMCSA	Federal Motor Carrier Safety Administration
HAC	hypothetical accident conditions
HMTA	Hazardous Materials Transportation Act
HRCQ	highway route controlled quantity
IAEA	International Atomic Energy Agency
INL	Idaho National Laboratory
LSA	low specific activity
MOU	Memorandum of Understanding
NCT	normal conditions of transport
NNSA	National Nuclear Security Administration
NRC	U.S. Nuclear Regulatory Commission
PHMSA	Pipeline and Hazardous Materials Safety Administration
QA	quality assurance
SARP	Safety Analysis Report for Packaging
SCO	surface contaminated object
SNF	spent nuclear fuel
TSD	Transportation Safety Document

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## 1.0 Introduction

Microreactors are very small nuclear reactors with a power output of 20MWe or less and are designed to be factory-built, modular in nature, and highly portable. The U.S. Department of Energy (DOE) is supporting the U.S. advanced reactor industry through funding, legislation and regulatory development in order to actively pursue several microreactor design concepts. The U.S. Department of Defense (DOD) also shares great interest in microreactor design concepts as its military operations become more energy intensive and require portable, dense power sources. Remote rural communities in the U.S. that rely on diesel generators for electricity are also considering microreactors as a source of reliable, zero-carbon energy capable of operation for several years without refueling. These reactors are typically intended for independent operation applications that include power for remote locations, mobile backup power, mining operations, military installations, space missions, desalination and emergency power supplies in support of disaster relief operations.

Idaho National Laboratory (INL) has been identified to support demonstrations of microreactor technology due to its well-established track record for nuclear facility operations, existing green field sites and world-class nuclear R&D experimental facilities and capabilities to support demonstration needs, a well-characterized site with a controlled emergency planning zone and mechanisms for the necessary U.S. Nuclear Regulatory Commission (NRC) licensing and DOE-authorization of its facilities as appropriate. INL is collaborating with major stakeholders and other national laboratories to develop, test, and demonstrate near-term microreactor definitions with an objective to significantly enhance the technology readiness level for direct application in the next three to five years. In support of such demonstrations, the DOE Office of Nuclear Engineering (DOE-NE) is supporting research and development as well as programmatic efforts in multiple areas related to microreactor technology including the safe and secure storage, transportation and disposition of spent nuclear fuel (SNF) generated in microreactor technology demonstrations. Modes of transportation that are being considered include but are not limited to air, barge, road, and rail. The required transport definition and associated packaging regulatory requirements will change during the course of the reactor demonstration itself based on initiation of a neutron fluence during the demonstration. As such, Type AF as well as Type B packaging definitions will likely need to be considered as part of the demonstration. The objective of this report is to identify and document applicable regulations, the appropriate regulatory authority, and the associated framework for microreactor transport. When more detailed information on possible origins, destinations, favorable transport modes, and reactor definitions are known, documentation will be updated to reflect a more detailed framework.

Sections 2 and 3 of this report summarize U.S. Department of Transportation (DOT) and NRC regulations related to the transportation of Class 7 (radioactive) materials. These sections concentrate on the transport of fissile material packages and Type B packages, which would be most applicable to the transport of a microreactor before and after irradiation. Section 4 summarizes DOE hazardous and radioactive material transportation regulations. Section 5 summarizes U.S. Coast Guard regulations related to the transport of radioactive material. Section 6 discusses state requirements for the permitting of oversize and/or overweight truck shipments. Section 7 presents detailed schedules of requirements for transporting fissile material packages and Type B packages based on NRC and DOT regulations. The schedules are presented in a two-column format, the right column is the regulatory requirement and the left column is the citation of the regulation in which the requirement is found.

## 2.0 U.S. Department of Transportation

The Hazardous Materials Transportation Act (HMTA) gives the Secretary of the U.S. Department of Transportation the authority to regulate the transportation of hazardous materials. The Pipeline and Hazardous Materials Safety Administration (PHMSA) within the DOT has been delegated the responsibility for the hazardous materials regulations.

The hazardous materials regulations are applicable to the transportation of hazardous materials in commerce and apply to the following activities:

- Transport by interstate, intrastate, and foreign carriers by rail car, aircraft, motor vehicle and vessel.
- Shipper's pre-transportation activities to present for shipment a hazardous material in a package, container, rail car, aircraft, motor vehicle or vessel with accompanying marking, labeling, placarding and shipping papers.
- The manufacture, fabrication, marking, maintenance, reconditioning, repairing or testing of a package or container which is represented, marked, certified or sold for use in the transportation of hazardous materials.

Hazardous materials regulations define nine classes of hazardous materials; radioactive material is denoted Class 7. Sections of the hazardous material regulations specific to Class 7 radioactive materials are:

- 49 CFR 173, Shippers—General Requirements for Shipments and Packagings, Subpart I (§173.401-173.477), Class 7 (Radioactive) Materials
- 49 CFR 174, Carriage by Rail, Subpart K (§174.700-174.750), Detailed Requirements for Class 7 (Radioactive) Materials
- 49 CFR 175, Carriage by Aircraft, Subpart C (§175.700-175.706), Specific Regulations Applicable According to Classification of Material
- 49 CFR 176, Carriage by Vessel, Subpart M (§176.700-176.720), Detailed Requirements for Radioactive Materials
- 49 CFR 177, Carriage by Public Highway, Subpart B (§177.842), Class 7 (Radioactive) Material
- 49 CFR 178, Specifications for Packagings, Subpart K (§178.350) Specifications for Packagings for Class 7 (Radioactive) Materials

The DOT Federal Motor Carrier Safety Administration (FMCSA) has additional requirements for transporting radioactive materials by highway. These requirements include:

- 49 CFR 385, Safety Fitness Procedures, Subpart E (§385.401-385.423), Hazardous Materials Safety Permits

- 49 CFR 397, Transportation of Hazardous Materials; Driving and Parking Rules, Subpart D (§397.101-397.103), Routing of Class 7 (Radioactive Materials)

## **2.1 49 CFR 171, General Information, Regulations, and Definitions**

49 CFR Part 171 contains general information, regulations, and definitions associated with hazardous material transportation.

## **2.2 49 CFR 172, Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements**

49 CFR Part 172 contains the hazardous materials table, requirements for shipping papers, marking, labeling, placarding, emergency response information, training, and safety and security plans. 49 CFR 172.820 contains safety and security planning requirements for rail shipments of highway route controlled quantities (HRCQ) of radioactive material, including routing. 49 CFR 172, Appendix D contains rail risk analysis factors to be used by rail carriers in determining these routes.

## **2.3 49 CFR 173, Shippers—General Requirements for Shipments and Packagings**

49 CFR 173, Subpart I contains requirements for the packaging and transportation of Class 7 (radioactive) materials. Topics addressed include:

- 173.403 – Definitions.
- 173.410 – General design requirements.
- 173.411 – Industrial packages.
- 173.412 – Additional design requirements for Type A packages.
- 173.413 – Requirements for Type B packages.
- 173.415 – Authorized Type A packages.
- 173.416 – Authorized Type B packages.
- 173.417 – Authorized fissile materials packages.
- 173.418 – Authorized packages—pyrophoric Class 7 (radioactive) materials.
- 173.419 – Authorized packages—oxidizing Class 7 (radioactive) materials.
- 173.420 – Uranium hexafluoride (fissile, fissile excepted and non-fissile).
- 173.421 – Excepted packages for limited quantities of Class 7 (radioactive) materials.

- 173.422 – Additional requirements for excepted packages containing Class 7 (radioactive) materials.
- 173.423 – Requirements for multiple hazard limited quantity Class 7 (radioactive) materials.
- 173.424 – Excepted packages for radioactive instruments and articles.
- 173.425 – Table of activity limits—excepted quantities and articles.
- 173.426 – Excepted packages for articles containing natural uranium or thorium.
- 173.427 – Transport requirements for low specific activity (LSA) Class 7 (radioactive) material and surface contaminated objects (SCO).
- 173.428 – Empty Class 7 (radioactive) materials packaging.
- 173.431 – Activity limits for Type A and Type B packages.
- 173.433 – Requirements for determining basic radionuclide values, and for the listing of radionuclides on shipping papers and labels.
- 173.434 – Activity-mass relationships for uranium and natural thorium.
- 173.435 – Table of  $A_1$  and  $A_2$  values for radionuclides.
- 173.436 – Exempt material activity concentrations and exempt consignment activity limits for radionuclides.
- 173.441 – Radiation level limitations and exclusive use provisions.
- 173.442 – Thermal limitations.
- 173.443 – Contamination control.
- 173.447 – Storage incident to transportation— general requirements.
- 173.448 – General transportation requirements.
- 173.453 – Fissile materials—exceptions.
- 173.457 – Transportation of fissile material packages—specific requirements.
- 173.459 – Mixing of fissile material packages with non-fissile or fissile-excepted material packages.
- 173.461 – Demonstration of compliance with tests.
- 173.462 – Preparation of specimens for testing.
- 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 Class 7 (radioactive) materials.
- 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 Class 7 (radioactive) materials.
- 173.476 – Approval of special form Class 7 (radioactive) materials.
- 173.477 – Approval of packagings containing greater than 0.1 kg of non-fissile or fissile-excepted uranium hexafluoride.

## **2.4 49 CFR 174, Carriage by Rail**

49 CFR 174.700, 174.715, and 174.750 contain requirements for special handling of packages of Class 7 (radioactive) materials, cleanliness of transport vehicles after use, and incidents involving leakage.

## **2.5 49 CFR 175, Carriage by Aircraft**

49 CFR 175.700 through 175.706 contain special limitations and requirements for packages of Class 7 (radioactive) materials, requirements for separation distances in passenger-carrying and cargo aircraft, other special requirements for the acceptance and carriage of packages of Class 7 (radioactive) materials, and requirements for plutonium shipments, contamination, and separation distances for undeveloped film.

## **2.6 49 CFR 176, Carriage by Vessel**

49 CFR 176.700, 176.704, 176.708, 176.710, 176.715, and 176.720 contain requirements for general stowage, transport indices and criticality safety indices, segregation distances, care following leakage or shifting of radioactive materials, contamination control, and requirements for carriage of irradiated fuel, plutonium, or high-level radioactive waste in international transportation.

## **2.7 49 CFR 177, Carriage by Public Highway**

49 CFR 177.842 and 177.843 contain requirements for the loading and segregation of packages of Class 7 (radioactive) materials and the contamination of vehicles.

## **2.8 49 CFR 178, Specifications for Packagings**

49 CFR 178.350 contains requirements for Specification 7A packaging.

## **2.9 49 CFR 385, Subpart E, Hazardous Materials Safety Permits**

49 CFR 385, Subpart E contains requirements for hazardous materials safety permits. A highway route controlled quantity truck shipment requires a hazardous materials safety permit [49 CFR 385.403(a)]. Operational requirements associated with this permit include a written route plan and a pre-trip Commercial Vehicle Safety Alliance (CVSA) Level VI inspection.

## **2.10 49 CFR 397, Subpart D, Routing of Class 7 (Radioactive) Materials**

49 CFR 397, Subpart D contains requirements for the routing of Class 7 (radioactive) materials, including requirements for motor carriers and drivers (49 CFR 397.101) and requirements for State routing designations (49 CFR 397.103). 49 CFR 397.101(a) contains requirements for the routing of placarded shipments and 49 CFR 397.101(b) contains requirements for highway route controlled quantity shipments.

## 3.0 U.S. Nuclear Regulatory Commission

The NRC has responsibility for safety in the possession, use and transfer (including transport) of by-product, source, and special nuclear materials, i.e., “licensed material.” Due to this overlap in statutory authorities of NRC and DOT, the two Agencies signed a 1979 Memorandum of Understanding (MOU) with regard to regulation of the transport of radioactive material. The principal objective of the MOU was to avoid conflicting and duplicative regulations and to clearly delineate the areas in which each Agency establishes regulations (PHMSA 2008).

### 3.1 10 CFR 71

In 10 CFR Part 71 has promulgated regulations for the packaging and transportation of radioactive material. This includes approval of fissile material packages and Type B packages, which would be most applicable to the transport of a microreactor before and after irradiation. NRC has adopted by reference (10 CFR 71.5) portions of the DOT regulations, enabling NRC to inspect its licensees for compliance with DOT regulations applicable to shipper/licensees and to take enforcement actions on violations.

NRC package approval standards include general standards applicable to all packages, and requirements related to the normal conditions of transport (NCT) and to hypothetical accident conditions (HAC). NRC regulations also contain special requirements for Type B packages containing more than  $10^5$  A<sub>2</sub> and plutonium air shipments. A microreactor will likely exceed this A<sub>2</sub> threshold after operation and will likely be required to meet additional deep submersion requirements as identified in 10 CFR 71.61, and will definitely be HRCQ. Finally, the NRC regulations in 10 CFR 71.41(c) and (d) may assist an applicant in shipping a microreactor containing spent nuclear fuel as a single unit.

### 3.2 10 CFR 73

In 10 CFR Part 73, NRC has promulgated regulations for the physical protection of plants and materials. Included in these regulations are requirements for the physical protection of special nuclear material in transit and requirements for the physical protection of irradiated reactor fuel in transit. The objective of the physical protection system for shipments is to minimize the potential for theft, diversion, or radiological sabotage and to facilitate the location and recovery of shipments that may come under control of unauthorized individuals.

NRC (2013) presents detailed guidance for the physical protection of irradiated reactor fuel (spent nuclear fuel) in transit, including approval of shipment routes, preplanning and coordination of shipments, advance notification of shipments, communications, arrangements with local law enforcement agencies, armed escorts, shipment logs, and procedures training and control of information. NRC (2013) also presents requirements by transport mode, e.g., road, rail, and vessel. Also discussed in this document are background investigations for unescorted access to spent nuclear fuel in transit.

### 3.3 NRC Regulatory Guides and Standard Review Plans

NRC regulatory guides provide guidance to licensees and applicants on implementing specific parts of the NRC’s regulations, techniques used by the NRC staff in evaluating specific problems or postulated accidents, and data needed by the staff in its review of applications for permits or licenses. Regulatory guides specific to transportation include:

- Regulatory Guide 7.4, Revision 1, Leakage Tests on Packages for Shipment of Radioactive Materials (NRC 2012a)
- Regulatory Guide 7.6, Revision 1, Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels (NRC 1978)
- Regulatory Guide 7.7, Revision 1, Administrative Guide for Verifying Compliance with Packaging Requirements for Shipments of Radioactive Materials (NRC 2012b)
- Regulatory Guide 7.8, Revision 1, Load Combinations for the Structural Analysis of Shipping Casks for Radioactive Material (NRC 1989)
- Regulatory Guide 7.9, Revision 2, Standard Format and Content of Part 71 Applications for Approval of Packages for Radioactive Material (NRC 2005a)
- Regulatory Guide 7.10, Revision 3, Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material (NRC 2015)
- Regulatory Guide 7.11, Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m) (NRC 1991a)
- Regulatory Guide 7.12, Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater than 4 Inches (0.1 m) But Not Exceeding 12 Inches (0.3 m) (NRC 1991b)

NRC has also issued standard review plans for transportation for radioactive material. Two standard review plans provide guidance for the review and approval of applications for packages used to transport radioactive material (other than irradiated nuclear fuel) under 10 CFR Part 71:

- Standard Review Plan for Transportation Packages for Radioactive Material, NUREG-1609 (NRC 1999)
- Standard Review Plan for Transportation Packages for MOX-Radioactive Material, NUREG-1609, Supplement 1 (NRC 2005b)

Two standard review plans provide guidance for the review and approval of applications for packages used to transport spent nuclear fuel under 10 CFR Part 71:

- Standard Review Plan for Transportation Packages for Spent Nuclear Fuel, NUREG-1617 (NRC 2000)
- Standard Review Plan for Transportation Packages for MOX Spent Nuclear Fuel, NUREG-1617, Supplement 1 (NRC 2005c)



## 4.0 U.S. Department of Energy

The DOE has broad authority under the Atomic Energy Act (AEA) to regulate activities involving radioactive materials that are undertaken by the DOE or on its behalf, including the transportation of radioactive materials. In most cases that do not involve national security or other critical interests, the DOE uses commercial carriers that undertake its shipments subject to regulation by DOT and NRC as appropriate. However, the DOE exercises its AEA authority to regulate certain Departmental shipments, including shipments by government employees and onsite transfers. In all cases, the DOE's packaging and transportation activities must be conducted in a manner that achieves an equivalent level of safety to that required by DOT and NRC for comparable commercial shipments.

DOE regulates its shipments through DOE Orders and other directives which establish the Department's policies, requirements, and responsibilities for Departmental elements and contractors. In instances where DOE uses a commercial carrier, transportation activities are regulated by DOT.

DOE Order 460.1D requires that DOE's packaging and transportation activities achieve an equivalent level of safety whether they are regulated by DOE or by NRC and DOT. DOE Order 460.1D addresses the offsite safety requirements for use of Type B or fissile material packages and states that when using a Type B or fissile material packaging with contents authorized by the Certificate of Compliance (CoC), as certified by the DOE Certifying Official (CO), NNSA CO or the NRC, DOE elements must meet the conditions specified in the CoC for the packaging issued by the DOE CO, NNSA CO or NRC and prior to first use, register in writing with the DOE CO or the NNSA CO, as appropriate. For packagings certified by the NRC and for which neither DOE nor NNSA is the certificate holder, DOE elements must register with the DOE CO, and NNSA elements must register with the NNSA CO.

For a new DOE Type B or fissile material packaging certificate, or a revision, renewal, or amendment to an existing certificate, DOE elements must submit an application to the DOE CO or the NNSA CO, as appropriate. The application must be supported by a Safety Analysis Report for Packaging (SARP). The SARP must adequately describe the proposed package in sufficient detail to identify the package accurately in accordance with 10 CFR 71.33 and provide a sufficient basis for evaluation of the package in accordance with 10 CFR 71.35. The application must also be supported by any other documentation needed to demonstrate the package meets the requirements of 10 CFR Part 71, Subparts D, E, F, G, and H, and any other applicable standards for certification.

For a new NRC packaging certificate, or an NRC special package authorization (in accordance with 10 CFR 71.41(d)), DOE elements must file a request for a new certificate with the DOE CO, and NNSA elements must file a request for a new certificate with the NNSA CO.

DOE Order 460.1D also requires that each DOE element that participates in the use, design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, and modification of Type B or fissile materials packaging must have and maintain a quality assurance (QA) program in accordance with 10 CFR Part 71, Subpart H that is approved by the NRC or approved by the DOE CO for DOE elements or by the NNSA CO for NNSA elements, prior to the performance of those operations.

DOE Order 460.1D also addresses onsite transportation safety requirements. Onsite transfer of hazardous materials, including radioactive materials, must be conducted in accordance with the following:

- QA requirements in Order 414.1D, Quality Assurance, and 10 CFR Part 830, as appropriate.
- 49 CFR Parts 171-180 and the relevant federal regulations governing each mode of transportation, or
- A Transportation Safety Document (TSD) approved by the Head of the Operations Office or Field Office/Site Office Manager, as appropriate. Requirements associated with the TSD include:
  - The TSD must describe the methodology and compliance process to meet equivalent safety for any deviation from 49 CFR Parts 171-180 and 49 CFR Parts 350-399.
  - For onsite transfers involving nuclear facility Hazard Category 2 or 3 quantities, the TSD must comply with the Safety Basis Requirements of 10 CFR Part 830, Subpart B.
  - For multiple-tenant DOE/NNSA sites, transportation safety documents for several contractor organizations may be combined into a single TSD.

DOE Order 460.2A states that DOE organizations must conduct operations in compliance with all applicable international, Federal, State, local, and Tribal laws, rules, and regulations governing materials transportation that are not inconsistent with Federal regulations. It is DOE policy that, notwithstanding the exemptions available through the national security provisions [see 49 CFR 173.7(b)] shipments under this provision will comply with the requirements of 49 CFR Parts 100-185, except those that infringe on maintenance of classified information.

DOE Manual 460.2-1A establishes a set of standard transportation practices for DOE organizations to use in planning and executing offsite shipments of radioactive materials including radioactive waste. DOE is committed to meeting or exceeding all NRC or DOT requirements that apply to comparable commercial shipments and, therefore, all Federal and contractor entities subject to DOE Manual 460.2-1A must act in accordance with this policy by performing transportation activities in a manner that meets or exceeds any such requirements, except as otherwise specified by DOE Manual 460.2-1A. In particular, DOE Manual 460.2-1A does not apply to onsite shipments of radioactive material.

As discussed in DOE Order 460.1D and 460.2A, DOE has committed to meeting or exceeding DOT and NRC transportation requirements. Therefore, the schedules contained in Section 7 were developed based on DOT and NRC requirements.

## 5.0 U.S. Coast Guard

The U.S. Coast Guard (USCG) is the lead federal agency for maritime homeland security and has broad authority related to the protection and security of vessels, harbors, and waterfront facilities (see 33 CFR Part 6). 33 CFR 165 also allows the USCG to establish Regulated Navigation Areas (RNA) and Limited Access Areas. RNAs are water areas within a defined boundary for which regulations for vessels navigating within the area have been established. RNAs usually prescribe what type or size of vessels may enter an area or in what manner they must navigate. Limited access areas consist of safety zones, security zones, and restricted waterfront areas. Definitions of safety and security zones are as follows:

- Generally, a safety zone is an area of water and/or land designated for a certain time for safety or environmental purposes. To protect human safety or the environment, a safety zone will limit public access to the area.
- Generally, a security zone is an area of water and/or land designated for a certain time to protect vessels, harbors, ports and waterfront facilities from sabotage, damage or injury due to subversive acts, accidents or other causes of a similar nature. To provide protection to a vessel or waterfront facility, a security zone will often surround a vessel or a waterfront facility, preventing other vessels from approaching.

The USCG has established safety and/or security zones at many nuclear power plants (see 33 CFR Part 165). 33 CFR Parts 101 and 103-106 also contain detailed maritime security requirements.

The USCG has also published Navigation and Vessel Inspection Circular No. 2-87, Domestic Barge Transportation of Radioactive Materials/Nuclear Waste (USCG 1987). This circular references American National Standards Institute (ANSI) Standard N14.24-1985, Highway Route Controlled Quantities of Radioactive Materials – Domestic Barge Transport, which identifies the organizations, equipment, operations, and documentation involved in barge shipments of radioactive materials between U.S. ports by inland waterways and in coastwise and ocean service. The Standard includes requirements pertaining to:

- Selection of the cask, barge, and towing vessel;
- Certification and documentation;
- Radiological and non-radiological operations;
- Insurance;
- Emergency planning; and
- Physical protection and security of the shipment.

While ANSI N.14-24 has been withdrawn, as a statement of USCG policy, it may also be used by Captains of the Port when issuing permits and controlling the movement of the barge.

## 6.0 States

It is possible that a microreactor truck shipment could be oversized and/or overweight. The permitting of oversized or overweight truck shipments is done at the state level. A vehicle and load is considered oversized when the vehicle and the cargo it carries exceed the legal dimensions of length or width, as defined by federal requirements or length, height, or width as defined by state requirements for the state in which the vehicle will be traveling (GAO 2015). A vehicle and load is considered overweight when the vehicle and the cargo it carries exceed the legal weight limit as defined by federal and state requirements (GAO 2015). A vehicle and load is considered a super load when its dimensions and weight exceed the dimensions and weight established for typical oversized and overweight loads. The dimensions and weights that qualify as a super load are set by the states and a super load is subject to additional state permitting requirements over and above the requirements for typical oversized and overweight vehicles and loads.

Permitting summaries are available in the *Vehicle Sizes and Weights Manual* (J.J. Keller and Associates, Inc. 2013) and the electronic supplement to *Transportation Safety: Federal Highway Administration Should Conduct Research to Determine Best Practices in Permitting Oversize Vehicles* (GAO 2015). The electronic supplement is available at <http://www.gao.gov/special.pubs/gao-15-235sp/index.htm>.

## 7.0 Schedules

The schedules presented in this section contain specific regulatory requirements for the transport of fissile material packages and Type B packages. Schedules for common provisions of transportation regulations and radioactive material package schedules are also presented.

The schedules do not include the requirements for low specific activity (LSA) shipments, surface contaminated object (SCO) shipments, uranium hexafluoride shipments, import and export shipments, shipments by passenger aircraft, or special form shipments (i.e., shipments were assumed to be normal form) because these types of shipments are unlikely to be relevant to microreactor shipments. In addition, requirements for Industrial Packages (i.e., IP-1, IP-2, and IP-3) or Empty packages are not listed because these packages are not likely to be relevant to microreactor shipments. The NRC physical protection requirements specified in 10 CFR Part 37 are also not listed because these requirements are unlikely to be relevant to microreactor shipments.

The Schedules are patterned after similar schedules presented in Cook et al. (1999) and IAEA (2015) and presented in a two-column format, the right column is the regulatory requirement and the left column is the citation of the regulation in which the requirement is found. In some cases, the regulatory requirement may be paraphrased from the actual regulations for simplicity and conciseness. In general, the schedules are organized into sections on materials, packaging/package, radiation, contamination, decontamination, mixed content, loading and segregation, marking and labeling, placarding, transport documents, storage and dispatch, carriage, and other provisions.

### 7.1 Common Provisions for Fissile Radioactive Material and Radioactive Material in Type B Packages Schedules

This section contains the common provisions for transporting fissile material and Type B packages. Typical identification numbers associated with fissile packages include UN 3327, UN 3328, UN 3329, and UN 3331. Typical identification numbers associated with Type B packages include UN 3328 and UN 3329.

Citation	Requirement
	<b>1. MATERIALS</b>
49 CFR 173.403	(a) Radioactive material means any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table in 49 CFR 173.436 or values derived according to the instructions in 49 CFR 173.433.
49 CFR 173.403	(b) Type A quantity means a quantity of Class 7 (radioactive) material, the aggregate radioactivity which does not exceed $A_1$ for special form Class 7 (radioactive) material of $A_2$ for normal form Class 7 (radioactive) material, where $A_1$ and $A_2$ values are given in 49 CFR 173.435 or are determined in accordance with 49 CFR 173.433.

Citation	Requirement
49 CFR 173.403	(c) Type B quantity means a quantity of material greater than a Type A quantity.
49 CFR 173.403	(d) $A_1$ means the maximum activity of special form Class 7 (radioactive) material permitted in a Type A package. This value is either listed in 49 CFR 173.435 or may be derived in accordance with the procedures prescribed in 49 CFR 173.433.
49 CFR 173.403	(e) $A_2$ means the maximum activity of Class 7 (radioactive) material, other than special form material, LSA material, and SCO, permitted in a Type A package. This value is either listed in 49 CFR 173.435 or may be derived in accordance with the procedures prescribed in 49 CFR 173.433.
49 CFR 173.435 10 CFR 71, Appendix A 49 CFR 173.433(b) 10 CFR 71, Appendix A(II)	(f) $A_1$ and $A_2$ values for radionuclides are listed in 49 CFR 173.435 and 10 CFR 71 Appendix A, Table A-1. For unlisted radionuclides, the values in 49 CFR 173.433, Table 7 may be used. Alternatively, other values may be approved by the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Associate Administrator for Hazardous Materials Safety, or U.S. Nuclear Regulatory Commission (NRC).
49 CFR 173.403	(g) Fissile material means plutonium-239, plutonium-241, uranium-233, uranium-235, or any combination of these radionuclides. Fissile material means the fissile nuclides themselves, not material containing fissile nuclides, but does not include: Unirradiated natural uranium or depleted uranium; and natural uranium or depleted uranium that has been irradiated in thermal reactors only. Certain exceptions for fissile materials are provided in 49 CFR 173.453.
49 CFR 173.403	(h) Normal form Class 7 (radioactive) material means Class 7 (radioactive) which has not been demonstrated to qualify as "special form Class 7 (radioactive) material."
49 CFR 173.403	(i) Special form Class 7 (radioactive) material means either an indispersible solid radioactive material or a sealed capsule containing radioactive material which satisfies the following conditions: (1) It is either a single solid piece or a sealed capsule containing radioactive material that can be opened only by destroying the capsule; (2) The piece or capsule has at least one dimension not less than 5 mm (0.2 in); and (3) It satisfies the test requirements of 49 CFR 173.469.
49 CFR 173.403	(j) Natural thorium means thorium with the naturally occurring distribution of thorium isotopes (essentially 100 percent by weight of thorium-232).
49 CFR 173.403	(k) Unirradiated thorium means thorium containing not more than $10^{-7}$ grams uranium-233 per gram of thorium-232.
49 CFR 173.403	(l) Unirradiated uranium means uranium containing not more than $2 \times 10^3$ Bq of plutonium per gram of uranium-235, not more than $9 \times 10^6$ Bq of fission products per gram of uranium-235 and not more than $5 \times 10^{-3}$ g of uranium-236 per gram of uranium-235.

Citation	Requirement
49 CFR 173.403	<p>(m) Uranium—natural, depleted or enriched means the following:</p> <p>(1)(i) “Natural uranium” means uranium (which may be chemically separated) containing the naturally occurring distribution of uranium isotopes (approximately 99.28% uranium-238 and 0.72% uranium-235 by mass).</p> <p>(ii) “Depleted uranium” means uranium containing a lesser mass percentage of uranium-235 than in natural uranium.</p> <p>(iii) “Enriched uranium” means uranium containing a greater mass percentage of uranium-235 than 0.72%.</p> <p>(2) For each of these definitions, a very small mass percentage of uranium-234 may be present.</p>
49 CFR 173.476	<p>(n) Each offeror of special form material must retain the safety analysis, including test documentation for at least two years after the latest shipment. An IAEA Competent Authority Certificate of Approval may be used to meet this requirement.</p>
49 CFR 173.461	<p>(o) Required material characteristics (e.g., special form) may be demonstrated using the methods prescribed in 49 CFR 173.461.</p>
49 CFR 173.403	<p>(p) Highway route controlled quantity means a quantity within a single package which exceeds:</p> <p>(1) 3,000 times the <math>A_1</math> value of the radionuclides as specified in 49 CFR 173.435 for special form Class 7 (radioactive) material;</p> <p>(2) 3,000 times the <math>A_2</math> value of the radionuclides as specified in 49 CFR 173.435 for normal form Class 7 (radioactive) material; or</p> <p>(3) 1,000 TBq (27,000 Ci), whichever is least.</p>
	<p><b>2. PACKAGING/PACKAGE</b></p>
49 CFR 173.403	<p>(a) Packaging means, for Class 7 (radioactive) materials, the assembly of components necessary to ensure compliance with the packaging requirements of this subpart. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, service equipment for filling, emptying, venting and pressure relief, and devices for cooling or absorbing mechanical shocks. The conveyance, tie-down system, and auxiliary equipment may sometimes be designated as part of the packaging.</p>
49 CFR 173.403	<p>(b) “Type A package” means a packaging that, together with its radioactive contents limited to <math>A_1</math> or <math>A_2</math> as appropriate, meets the requirements of 49 CFR 173.410 and 49 CFR 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 49 CFR 173.465 or 49 CFR 173.466, as appropriate. A Type A package does not require Competent Authority approval.</p>
49 CFR 173.403	<p>(c) “Type B package” means a packaging designed to transport greater than an <math>A_1</math> or <math>A_2</math> quantity of radioactive material that, together with its radioactive contents, is designed to retain the integrity of containment and shielding required by this part when subjected to the normal conditions of transport and hypothetical accident test conditions set forth in 10 CFR Part 71.</p>
49 CFR 173.403	<p>(d) “Type B(U) package” means a Type B packaging that, together with its radioactive contents, for international shipments requires unilateral approval only</p>

Citation	Requirement
	of the package design and of any stowage provisions that may be necessary for heat dissipation.
49 CFR 173.403	(e) "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 kPa/cm <sup>2</sup> (100 lb/in <sup>2</sup> ) gauge or a relief device which would allow the release of Class 7 (radioactive) material to the environment under the hypothetical accident conditions specified in 10 CFR Part 71.
10 CFR 71.4	(f) Type B package means a Type B packaging together with its radioactive contents. On approval, a Type B package design is designated by NRC as B(U) unless the package has a maximum normal operating pressure of more than 700 kPa (100 lb/in <sup>2</sup> ) gauge or a pressure relief device that would allow the release of radioactive material to the environment under the tests specified in 10 CFR 71.73 (hypothetical accident conditions), in which case it will receive a designation B(M). B(U) refers to the need for unilateral approval of international shipments; B(M) refers to the need for multilateral approval of international shipments. There is no distinction made in how packages with these designations may be used in domestic transportation. To determine their distinction for international transportation, see DOT regulations in 49 CFR Part 173. A Type B package approved before September 6, 1983, was designated only as Type B. Limitations on its use are specified in 10 CFR 71.19.
49 CFR 173.403	(g) "Fissile material package" means a packaging, together with its fissile material contents, which meets the requirements for fissile material packages described in 10 CFR 71, Subpart E. A fissile material package may be a Type AF package, a Type B(U)F package, or a Type B(M)F package.
49 CFR 173.442	(h) Thermal Limitations. A package of Class 7 (radioactive) material must be designed, constructed, and loaded so that— (a) The heat generated within the package by the radioactive contents will not, during conditions normally incident to transport, affect the integrity of the package; and (b) The temperature of the accessible external surfaces of the loaded package will not, assuming still air in the shade at an ambient temperature of 38 °C (100 °F), exceed either— (1) 50 °C (122 °F) in other than an exclusive use shipment; or (2) 85 °C (185 °F) in an exclusive use shipment.
	<b>3. RADIATION</b>
49 CFR 173.441	(a) The maximum allowed radiation levels are shown in the table below.
49 CFR 173.441	(b) Packages exceeding a surface radiation level of 2 mSv/hr or a Transport Index of 10 may not be transported by aircraft except under special circumstances approved by DOT.



Type of Shipment	Radiation Level Limit				
	Transport Index	Package Surface	Vehicle Outer Surface (including top and bottom) <sup>1</sup>	2 m from Vehicle Outer Surface (excluding top and bottom) <sup>2</sup>	Normally Occupied Space
Non-Exclusive Use	10	2 mSv/hr (200 mrem/hr)	–	–	–
Exclusive Use	–	2 mSv/hr (200 mrem/hr) <sup>3</sup>	2 mSv/hr (200 mrem/hr)	0.1 mSv/hr (10 mrem/hr)	0.02 mSv/hr (2 mrem/hr) <sup>4</sup>

Notes:  
 (1) On flat-bed type of vehicles, 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 vehicle underside.  
 (2) On a flat-bed type of vehicle, a point 2 m (6.6') from the vertical planes projected by the outer edges of the vehicle.  
 (3) 10 mSv/h (1000 mrem/h) if the following conditions are met: the shipment is made in a closed transport type of vehicle; the package is secured within the vehicle so that its position remains fixed during transportation; and there are no loading or unloading operations between the beginning and end of operation.  
 (4) This provision does not apply to private carriers if exposed personnel under their control wear radiation dosimetry devices as part of a radiation protection program.

	<b>4. CONTAMINATION</b>
49 CFR 173.443(a)	(a) Non-fixed contamination on the external surfaces of packages must be kept as low as reasonably achievable and the wipe limits given below must not be exceeded (49 CFR 173.443, Table 9). Specific methods of performing the wipe are prescribed.
49 CFR 173.443(b)	(b) For packages transported as exclusive use shipments by rail or public highway only, the non-fixed (removable) radioactive contamination on any package at any time during transport may not exceed ten times the levels prescribed above. The levels at the beginning of transport may not exceed the values given in the table below.

Contaminant	Maximum Permissible Limits		
	Bq/cm <sup>2</sup>	µCi/cm <sup>2</sup>	dpm/cm <sup>2</sup>
Beta and gamma emitters and low toxicity alpha emitters	4	10 <sup>-4</sup>	240
All other alpha emitting radionuclides	0.4	10 <sup>-5</sup>	24

	<b>5. DECONTAMINATION</b>
	<b>Decontamination: General</b>
49 CFR 173.443(c)	(a) Each transport vehicle which exceeds the contamination limits above must be surveyed with appropriate radiation detection instruments after each use. A vehicle may not be returned to service until the radiation dose rate at each accessible surface is 0.005 mSv/h (0.5 mrem/h) or less, and there is no significant non-fixed (removable) radioactive surface contamination.
49 CFR 174.715 49 CFR 177.843	(b) A closed transport vehicle used solely for exclusive use transportation by highway or rail of Class 7 material packages may be returned to service 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/h (10 mrem/h) at the surface or 0.02 mSv/h (2 mrem/h) 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 in) 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.
	<b>Decontamination: Aircraft</b>
49 CFR 175.705	(a) A carrier shall take care to avoid possible inhalation, ingestion, or contact by any person with Class 7 (radioactive) materials that may have been released from their packagings.  (b) When contamination is present or suspected, the package containing a Class 7 material, any loose Class 7 material, associated packaging material, and any other materials that have been contaminated must be segregated as far as practicable from personnel contact until radiological advice or assistance is obtained from the U.S. Department of Energy or appropriate State or local radiological authorities.  (c) An aircraft in which Class 7 (radioactive) material has been released must be taken out of service and may not be returned to service or routinely occupied until the aircraft is checked for radioactive substances and it is determined that any radioactive substances present do not meet the definition of radioactive material, as defined in 49 CFR 173.403 of this subchapter, and it is determined in accordance with 49 CFR 173.443 of this subchapter that the dose rate at every accessible surface must not exceed 0.005 mSv per hour (0.5 mrem per hour) and there is no significant removable surface contamination.  (d) Each aircraft used routinely for transporting Class 7 materials shall be periodically checked for radioactive contamination, and an aircraft must be taken out of service if contamination exceeds the level specified in 49 CFR 175.705(c). The frequency of these checks shall be related to the likelihood of contamination and the extent to which Class 7 materials are transported.  (e) In addition to the reporting requirements of (49 CFR 171.15 and 49 CFR 171.16 of this subchapter and 49 CFR 175.31 of this part, an aircraft operator shall notify the offeror at the earliest practicable moment following any incident in which there has been breakage, spillage, or suspected radioactive contamination involving Class 7 (radioactive) materials shipments.

	<b>6. MIXED CONTENTS</b>
49 CFR 173.2 49 CFR 173.2a	(a) Radioactive materials that exceed the activity limits in 173.421 or 173.424, and that satisfy more than one hazard classification or division must be classified as Class 7 (radioactive materials) with the following exceptions:
49 CFR 173.2a(c)(1)	(1) A Class 1 (explosive) material combination must be assigned a division in Class 1.
49 CFR 173.2a(c)(2)	(2) A Division 5.2 (organic peroxide) material combination must be classified as Division 5.2.
49 CFR 173.2a(c)(3)	(3) A material that meets the definition of a wetted explosive must be classified as Division 4.1.
	<b>7. LOADING AND SEGREGATION</b>
	<b>Loading and Segregation: General</b>
49 CFR 173.448(a)	(a) Each shipment of Class 7 materials must be secured to prevent shifting during normal transportation conditions.
49 CFR 173.448(b)	(b) Except for the specific segregation requirements for rail, vessel, and highway (described later), or as otherwise required by the competent authority in the applicable certificate, a package of Class 7 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 W/m <sup>2</sup> 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.
49 CFR 173.448(c)	(c) Packages or overpacks bearing labels prescribed in 49 CFR 172.403 (RADIOACTIVE WHITE-I, RADIOACTIVE YELLOW-II, or RADIOACTIVE YELLOW-III) may not be carried in compartments occupied by passengers, except in those compartments exclusively reserved for couriers accompanying those packages.
49 CFR 173.448(d)	(d) Mixing of different kinds of packages that include fissile packages is authorized only in accordance with 49 CFR 173.459.
49 CFR 173.448(g)	(e) If an overpack is used to consolidate individual packages or to enclose a single package of Class 7 (radioactive) materials, the package(s) must comply with the packaging, marking, and labeling requirements of this subchapter, and: (1) The overpack must be labeled as prescribed in 49 CFR 172.403(h) of this subchapter; (2) The overpack must be marked as prescribed in 49 CFR 172, Subpart D and 49 CFR 173.25(a); and (3) The transport index of the overpack may not exceed 3.0 for passenger carrying aircraft shipments, or 10.0 for cargo-aircraft shipments.
49 CFR 173.442	(f) Packages must be 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

	<p>package; and</p> <p>(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:</p> <p>(1) 50°C (122°F) in other than an exclusive use shipment; or</p> <p>(2) 85°C (185°F) in an exclusive use shipment.</p>
	<b>Loading and Segregation: Aircraft</b>
49 CFR 175.702	(a) Specific separation distance requirements for packages containing Class 7 (radioactive) materials in cargo aircraft are listed in 49 CFR 175.702
	<b>Loading and Segregation: Plutonium by Aircraft</b>
49 CFR 175.705	<p>(a) Shipments of plutonium which are subject to 10 CFR 71.88(a)(4) must comply with the following:</p> <p>(a) Each package containing plutonium must be secured and restrained to prevent shifting under normal conditions.</p> <p>(b) A package of plutonium having a gross mass less than 40 kg (88 pounds) and both its height and diameter less than 50 cm (19.7 inches)—</p> <p>(1) May not be transported aboard an aircraft carrying other cargo required to bear a Division 1.1 label; and</p> <p>(2) Must be stowed aboard the aircraft on the main deck or the lower cargo compartment in the aft-most location that is possible for cargo of its size and weight, and no other cargo may be stowed aft of packages containing plutonium.</p> <p>(c) A package of plutonium exceeding the size and weight limitations in paragraph (b) of this section—</p> <p>(1) May not be transported aboard an aircraft carrying other cargo required to bear any of the following labels: Class 1 (all Divisions), Class 2 (all Divisions), Class 3, Class 4 (all Divisions), Class 5 (all Divisions), or Class 8; and</p> <p>(2) Must be securely cradled and tied down to the main deck of the aircraft in a manner that restrains the package against the following internal forces acting separately relative to the deck of the aircraft; Upward, 2g; Forward, 9g; Sideward, 1.5g; Downward, 4.5g.</p>
	<b>Loading and Segregation: Railroad</b>
49 CFR 174.700(b)	(a) The number of packages of Class 7 materials that may be transported by rail or stored at any single location is limited to a total transport index number of not more than 50. This provision does not apply to exclusive use shipments.
49 CFR 174.700(c)	(b) Each package of Class 7 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 Class 7 materials is present, the distance must be computed from the table contained in 49 CFR 174.700(c).
49 CFR 174.700(f)	(c) A person shall not remain unnecessarily in, on, or near a transport vehicle containing Class 7 materials.
	<b>Loading and Segregation: Vessel</b>

49 CFR 176.704(a)	(a) The sum of the transport indexes for all packages of radioactive materials on board a vessel may not exceed the limits in the table contained Table IIIA in 49 CFR 176.704.
49 CFR 176.704(d)	(b) The sum of the criticality safety indices for all packages and overpacks of fissile Class 7 (radioactive) materials on board a vessel may not exceed the limits contained in Table IIIB in 49 CFR 176.704.
49 CFR 176.83	(c) General segregation requirements are given in Table 176.83(b).
49 CFR 176.708	(d) The segregation distances which apply to the stowage of packages of Class 7 materials on board a vessel are contained in Table IV in 49 CFR 176.708.
	<b>Loading and Segregation: Highway</b>
49 CFR 177.842(a)	(a) The number of packages of Class 7 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 a 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.
49 CFR 177.842(b)	(b) Packages of Class 7 material bearing RADIOACTIVE YELLOW-II or RADIOACTIVE YELLOW-III labels may not be placed in a transport vehicle, storage location or in any other place closer than the distances shown in the table contained in 49 CFR 177.842 to any area which may be continuously occupied by any passenger, employee, or animal, nor closer than the distances shown in the table contained in 49 CFR 177.842 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 must 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 store room. (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.
49 CFR 177.842(d)	(c) Packages must be so blocked and braced that they cannot change position during conditions normally incident to transportation.
49 CFR 177.842(e)	(d) Persons should not remain unnecessarily in a vehicle containing Class 7 materials.
	<b>8. MARKING AND LABELING</b>
	<b>Marking and Labeling: General</b>
49 CFR 172.310	(a) Class 7 (radioactive) material package marking requirements are contained in 49 CFR 172.310.
49 CFR 173.471	(b) Marking requirements for NRC packages are contained in 49 CFR 173.471(b) and (c).

49 CFR 172.401(a)	(c) No package bearing a hazard label may be transported unless: (1) The package contains a material that is a hazardous material, and (2) The label represents a hazard of the hazardous material in the package.
49 CFR 172.401(b)	(d) No person may offer for transportation and no carrier may transport a package bearing any marking or label which by its color, design, or shape could be confused with or conflict with a label prescribed in 49 CFR 172.
49 CFR 172.402	(e) Additional labeling requirements are contained in 49 CFR 172.402, including requirements for subsidiary hazard labels, display of hazard class on labels, cargo aircraft only label, and class 7 (radioactive) material labels.
	<b>Marking and Labeling: Radioactive Labels</b>
49 CFR 172.436	(a) Description of RADIOACTIVE WHITE-I label
49 CFR 172.438	(b) Description of RADIOACTIVE YELLOW-II label
49 CFR 172.440	(c) Description of RADIOACTIVE YELLOW-III label
49 CFR 172.441	(d) Description of FISSILE label
49 CFR 172.450	(e) Description of EMPTY label
49 CFR 172.403(b) 49 CFR 172.403(c)	(f) The proper label to affix to a package of Class 7 material is based on the radiation level at the surface of the package and the transport index. The label to be applied must be the highest category required for any of the two determining conditions for the package as shown in the table contained in 49 CFR 172.403. 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 mSv/h (60 mrem/h) must bear a RADIOACTIVE YELLOW-III label.
49 CFR 172.403(f) 49 CFR 172.406(a) 49 CFR 172.406(e)(5)	(g) Each package labeled with a RADIOACTIVE label must have two of these labels, affixed to opposite sides (not the bottom) of the package, and near the proper shipping name marking if package dimensions are adequate. For freight containers, one of each required label must be displayed on or near the closure.
49 CFR 172.403(g)	(h) The following must be entered in the blank spaces on the RADIOACTIVE label: (1) Contents: The name of the radionuclides as taken from the listing of radionuclides in 49 CFR 173.435. For mixtures of radionuclides, use the guidance in 49 CFR 173.433(g) (2) Activity: Activity units must be expressed in appropriate SI units [e.g., Becquerels (Bq), Terabecquerels (TBq), etc.] or in both appropriate SI units and appropriate customary units [Curies (Ci), milliCuries (mCi), microcuries (uCi), etc.]. Abbreviations are authorized.

	(3) Transport index: If the measured TI is not greater than 0.05, the value may be considered to be zero.
	<b>Marking and Labeling: Overpacks</b>
49 CFR 172.403(h)	(a) If an overpack is used to consolidate individual packages of Class 7 materials, the packages must comply with the packaging, marking, and labeling requirements, and the overpack must be labeled RADIOACTIVE WHITE-I, RADIOACTIVE YELLOW-II, or RADIOACTIVE YELLOW-III, except as follows: (1) The "contents" entry on the label may state "mixed" unless each inside package contains the same radionuclide(s); (2) The "activity" entry on the label must be determined by adding together the number of Becquerels (curies) of the Class 7 materials packages contained therein; (3) For a non-rigid overpack, the required label together with required package markings must be affixed to the overpack by means of a securely attached, durable tag. The transport index must be determined by adding together the transport indexes of the Class 7 materials packages contained therein; and (4) For a rigid overpack, the transport index may be alternatively be determined by direct measurement taken by the person initially offering the packages contained within the overpack for shipment; (5) The category of the Class 7 label is based on the table contained in 49 CFR 172.403 and the maximum radiation level on the surface of the overpack. (6) For fissile material, the criticality safety index which must be entered on the overpack FISSILE label is the sum of the criticality safety indices of the individual packages in the overpack, as stated in the certificate of approval for the package design issued by the NRC or the U.S. Competent Authority.
49 CFR 173.25(a)(2) 49 CFR 172.404(b)	(b) The overpack must be marked with the proper shipping name and identification number, and labeled as required for each hazardous material contained therein unless markings and labels representative of each hazardous material in the overpack are visible.
49 CFR 173.25(a)(3) 49 CFR 172.312	(c) Each package subject to the orientation marking requirements must be marked with package orientation marking arrows on two opposite vertical sides of the overpack with the arrows pointing in the correct direction.
49 CFR 172.25(a)(4)	(d) The overpack is marked with a statement indicating that the inside (inner) packages comply with the prescribed specifications when specification packagings are required, unless specification markings on the inside packages are visible.
49 CFR 172.404	(e) When authorized hazardous materials having different hazard classes are packed within the same packaging, or within the same outside container or overpack, the packaging, outside container or overpack must be labeled for each class of hazard contained therein.
49 CFR 172.301(a)	(f) Each non-bulk package must be marked with the proper shipping name and identification number (preceded by "UN", "NA", or "ID" as appropriate) for the material as shown in the hazardous material table (49 CFR 172.101).
49 CFR 172.301(b)	(g) Each non-bulk packaging containing hazardous materials must be marked with its technical name in parentheses in association with the proper shipping name.

49 CFR 172.301(d)	(h) Consignee's or consignor's name and address. Each non-bulk package must be marked with the name and address of the consignor or consignee.
49 CFR 172.324	(i) For each non-bulk package that contains a hazardous substance, the letters "RQ" must be marked on the package in association with the proper shipping name.
	<b>9. PLACARDING</b>
49 CFR 172.556	(a) Description of radioactive placard
49 CFR 172.504(a)	(b) With few exceptions, each bulk packaging, freight container, unit load device, transport vehicle or rail car containing any RADIOACTIVE YELLOW-III labeled packages must be placarded on each side and each end with RADIOACTIVE placards.
49 CFR 172.507 49 CFR 172.527 49 CFR 173.403	(c) Each motor vehicle used to transport a package of highway route controlled quantity of radioactive material, must have the required RADIOACTIVE warning placard on a white square background surrounded by a black border.
49 CFR 172.505(d)	(d) Radioactive materials possessing secondary hazards may exhibit subsidiary placards. This may be done even when not required elsewhere in the regulations.
49 CFR 172.506	(e) Each person offering radioactive material for transportation by highway must provide the motor carrier with the required placards for that shipment, prior to or at the time the material is offered for transport. However, if the carrier's motor vehicle is already appropriately placarded, no action is needed.
49 CFR 172.508	(f) Each person offering radioactive material for transportation by rail must affix the required placards to the rail car containing the material. Placards which are on motor vehicles, transport containers or portable tanks may be used in satisfying this requirement.
49 CFR 172.516(a)	(g) Each placard on a motor vehicle or rail car must be readily visible from the direction it faces. However, placards are not required to be visible from the direction of another motor vehicle or rail car to which it is coupled.
49 CFR 172.516(b)	(h) The required placarding of the front of a motor vehicle may be on the front of a truck tractor instead of, or in addition to, the placarding on the front of the cargo body to which the truck-tractor is attached.
49 CFR 172.516(c)	(i) Placards must be securely attached and be maintained readily readable and visible.
49 CFR 172.516(d)	(j) Specifications for a placard holder are contained in 49 CFR 172, Appendix C.
49 CFR 172.516(e)	(k) A placard or placard holder may be hinged provided the required format, color, and legibility of the placard are maintained.



	<b>10. TRANSPORT DOCUMENTS</b>
	<b>Transport Documents: Shipping Papers</b>
49 CFR 172.200	Requirement for description of hazardous material.
49 CFR 172.201	Requirements for preparation and retention of shipping papers.
49 CFR 172.202	Requirements for description of hazardous material on shipping papers.
49 CFR 172.203	Requirements for additional descriptions on shipping papers.
49 CFR 172.203(d)	Detailed requirements for description of radioactive material on shipping papers.
49 CFR 172.204	Requirements for shipper's certification.
	<b>Transport Documents: Emergency Response Information</b>
49 CFR 172.600	Applicability and general requirements
49 CFR 172.602	Requirements for emergency response information.
49 CFR 172.604	Requirements for emergency response phone number.
49 CFR 172.606	Each carrier who transports or accepts for transportation a hazardous material for which a shipping paper is required shall instruct the operator of a motor vehicle, train, aircraft, or vessel to contact the carrier (e.g., by telephone or mobile radio) in the event of an incident involving the hazardous material.
	<b>11. STORAGE AND DISPATCH</b>
	No specific provisions.
	<b>12. CARRIAGE</b>
49 CFR 177.816(a)	(a) In addition to hazmat employee training, no carrier may transport a hazardous material by highway unless each hazmat employee who will operate a motor vehicle has received further training on the procedures necessary for the safe operation of that motor vehicle.
49 CFR 177.817(e)	(b) A driver of a motor vehicle containing hazardous material must ensure that the shipping papers are readily available and recognizable by authorities in the event of an accident or inspection.

<p>49 CFR 397.101(a)</p>	<p>(c) Except as provided in paragraph (b) of this section or in circumstances when there is only one practicable highway route available, considering operating necessity and safety, a carrier or any person operating a motor vehicle that contains a Class 7 (radioactive) material, as defined in 49 CFR 172.403, for which placarding is required under 49 CFR part 172 shall:</p> <p>(1) Ensure that the motor vehicle is operated on routes that minimize radiological risk;</p> <p>(2) Consider available information on accident rates, transit time, population density and activities, and the time of day and the day of week during which transportation will occur to determine the level of radiological risk; and</p> <p>(3) Tell the driver which route to take and that the motor vehicle contains Class 7 (radioactive) materials.</p>
<p>49 CFR 397.101(b)</p>	<p>(d) Except as otherwise permitted in this paragraph and in paragraph (f) of this section, a carrier or any person operating a motor vehicle containing a highway route controlled quantity of Class 7 (radioactive) materials, as defined in 49 CFR 173.403, shall operate the motor vehicle only over preferred routes.</p> <p>(1) For purposes of this subpart, a preferred route is an Interstate System highway for which an alternative route is not designated by a State routing agency; a State-designated route selected by a State routing agency pursuant to 49 CFR 397.103; or both of the above.</p> <p>(2) The motor carrier or the person operating a motor vehicle containing a highway route controlled quantity of Class 7 (radioactive) materials, as defined in 49 CFR 173.403, shall select routes to reduce time in transit over the preferred route segment of the trip. An Interstate System bypass or Interstate System beltway around a city, when available, shall be used in place of a preferred route through a city, unless a State routing agency has designated an alternative route.</p>
<p>49 CFR 397.101(c)</p>	<p>(e) A motor vehicle may be operated over a route, other than a preferred route, only under the following conditions:</p> <p>(1) The deviation from the preferred route is necessary to pick up or deliver a highway route controlled quantity of Class 7 (radioactive) materials, to make necessary rest, fuel or motor vehicle repair stops, or because emergency conditions make continued use of the preferred route unsafe or impossible;</p> <p>(2) For pickup and delivery not over preferred routes, the route selected must be the shortest-distance route from the pickup location to the nearest preferred route entry location, and the shortest-distance route to the delivery location from the nearest preferred route exit location. Deviation from the shortest-distance pickup or delivery route is authorized if such deviation:</p> <p>(i) Is based upon the criteria in paragraph (a) of this section to minimize the radiological risk; and</p> <p>(ii) Does not exceed the shortest-distance pickup or delivery route by more than 25 miles and does not exceed 5 times the length of the shortest-distance pickup or delivery route.</p> <p>(iii) Deviations from preferred routes, or pickup or delivery routes other than preferred routes, which are necessary for rest, fuel, or motor vehicle repair stops or because of emergency conditions, shall be made in accordance with the criteria in paragraph (a) of this section to minimize radiological risk, unless due to emergency conditions, time does not permit use of those criteria.</p>
<p>49 CFR 397.101(d)</p>	<p>(f) A carrier (or a designated agent) who operates a motor vehicle which contains a package of highway route controlled quantity of Class 7 (radioactive) materials, as defined in 49 CFR 173.403, shall prepare a written route plan and supply a copy before departure to the motor vehicle driver and a copy to the shipper</p>

	<p>(before departure for exclusive use shipments, as defined in 49 CFR 173.403, or within fifteen working days following departure for all other shipments). Any variation between the route plan and routes actually used, and the reason for it, shall be reported in an amendment to the route plan delivered to the shipper as soon as practicable but within 30 days following the deviation. The route plan shall contain:</p> <p>(1) A statement of the origin and destination points, a route selected in compliance with this section, all planned stops, and estimated departure and arrival times; and</p> <p>(2) Telephone numbers which will access emergency assistance in each State to be entered.</p>
49 CFR 397.101(e)	<p>(g) No person may transport a package of highway route controlled quantity of Class 7 (radioactive) materials on a public highway unless:</p> <p>(1) The driver has received within the two preceding years, written training on:</p> <p>(i) Requirements in 49 CFR Parts 172, 173, and 177 pertaining to the Class 7 (radioactive) materials transported;</p> <p>(ii) The properties and hazards of the Class 7 (radioactive) materials being transported; and</p> <p>(iii) Procedures to be followed in case of an accident or other emergency.</p> <p>(2) The driver has in his or her immediate possession a certificate of training as evidence of training required by this section, and a copy is placed in his or her qualification file (see 49 CFR 391.51), showing:</p> <p>(i) The driver's name and operator's license number;</p> <p>(ii) The dates training was provided;</p> <p>(iii) The name and address of the person providing the training;</p> <p>(iv) That the driver has been trained in the hazards and characteristics of highway route controlled quantity of Class 7 (radioactive) materials; and</p> <p>(v) A statement by the person providing the training that information on the certificate is accurate.</p> <p>(3) The driver has in his or her immediate possession the route plan required by paragraph (d) of this section and operates the motor vehicle in accordance with the route plan.</p>
49 CFR 397.101(f)	<p>(h) A person may transport irradiated reactor fuel only in compliance with a plan if required under 49 CFR 173.22(c) that will ensure the physical security of the material. Variation for security purposes from the requirements of this section is permitted so far as necessary to meet the requirements imposed under such a plan, or otherwise imposed by the U.S. Nuclear Regulatory Commission in 10 CFR Part 73.</p>
49 CFR 107.601-107.620	<p>(i) There are also registration requirements associated with highway route controlled shipments.</p>
	<p><b>13. OTHER PROVISIONS</b></p>
	<p><b>Training</b></p>
49 CFR 172.700-172.704	<p>49 CFR 172.700-172.704 contain training requirements for hazmat employees.</p>
	<p><b>Safety and Security Plans</b></p>

<p>49 CFR 172.800- 172.822</p>	<p>49 CFR 172.800-172.822 contain requirements for safety and security plans.</p>
<p>49 CFR 172.820</p>	<p>49 CFR 172.820 contains additional planning requirements for transportation by rail. These requirements are applicable to a highway route controlled quantity of Class 7 (radioactive) material and include a requirement to analyze the safety and security risks for rail transportation routes. Each calendar year, the safety and security risks present must be analyzed for the route and railroad facilities along the route. For purposes of this section, railroad facilities are railroad property including, but not limited to, classification and switching yards, storage facilities, and non-private sidings. The route analysis must be in writing and include the factors contained in 49 CFR 172, Appendix D. In performing the analysis, the rail carrier must seek relevant information from state, local, and tribal officials, as appropriate, regarding security risks to high-consequence targets along or in proximity to the route(s) utilized. The rail carrier must identify practicable alternative routes and analyze these routes if they exist. The written alternative route analysis must also consider: (i) safety and security risks presented by use of the alternative route(s); (ii) comparison of the safety and security risks of the alternative(s) to the primary rail transportation route, including the risk of a catastrophic release from a shipment traveling along each route; (iii) any remediation or mitigation measures implemented on the primary or alternative route(s); and (iv) potential economic effects of using the alternative route(s), including but not limited to the economics of the commodity, route, and customer relationship. In performing the analysis, the rail carrier should seek relevant information from state, local, and tribal officials, as appropriate, regarding security risks to high-consequence targets along or in proximity to the alternative routes. If a rail carrier determines that it is not appropriate to seek such relevant information, then it must explain its reasoning for that determination in its analysis.</p>
<p>49 CFR 172, Appendix D</p>	<p>49 CFR 172, Appendix D contains rail risk analysis factors to be used by rail carriers in determining these routes.</p>
<p>49 CFR 172.822</p>	<p>49 CFR 172.822 limits actions by states, local governments, and Tribes to prohibit use of a rail line for transportation of hazardous materials.</p>
	<p><b>Hazardous Materials Safety Permits</b></p>
<p>49 CFR 385.401- 385.423</p>	<p>49 CFR 385.401-385.423 contains requirements for hazardous materials safety permits.</p>
<p>49 CFR 385.403(a)</p>	<p>A highway route controlled quantity truck shipment requires a hazardous materials safety permit. Operational requirements associated with this permit include a written route plan and a pre-trip Commercial Vehicle Safety Alliance (CVSA) Level VI inspection.</p>
	<p><b>Licensing</b></p>
<p>10 CFR 30.41(a)</p>	<p>(a) Generally, radioactive material may only be transferred to those authorized to possess it and such authorization (or exemption) must be confirmed before transfer.</p>
<p>10 CFR 30.41(b)</p>	<p>Specifically, byproduct material may only be transferred by NRC (or Agreement State) licensees to: (1) The DOE;</p>

	<p>(2) The agency in an Agreement State which regulates radioactive material;</p> <p>(3) Anyone exempt for the licensing requirements of the Atomic Energy Act or the Agreement State;</p> <p>(4) Any person authorized to receive such byproduct material under the terms of a specific or general license issued by the NRC or Agreement State.</p> <p>(5) A person abroad in accordance with an NRC general export license;</p> <p>(6) Anyone else specifically authorized by the NRC in writing.</p>
10 CFR 30.41(c), 30.41(d)	The licensee transferring the radioactive material must verify that the transferee's license authorizes the receipt of the type, form, and quantity of the byproduct material transferred. Several methods are allowed, the simplest is to have and read a current copy of the transferee's license.
	<b>Quality Assurance</b>
49 CFR 173.474	<p>Prior to the first use of any packaging for the shipment of Class 7 material, the offeror must determine that:</p> <p>(1) The packaging meets the quality of design and construction requirements as specified; and</p> <p>(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.</p>
	Before each shipment of any radioactive materials package the offeror must ensure that:
49 CFR 173.475(a)	The packaging is proper for the contents to be shipped;
49 CFR 173.475(b)	The packaging is in unimpaired physical condition, except for superficial marks;
49 CFR 173.475(c)	Each closure device is properly installed, secured and free of defects;
49 CFR 173.475(d)	For fissile material, each moderator and neutron absorber, if required to be present is present and in proper condition;
49 CFR 173.475(e)	Each special instruction for filling, closing and preparation has been followed;
49 CFR 173.475(f)	Each closure, valve or other opening is properly closed and sealed;
49 CFR 173.475(g)	Each packaging containing liquid in excess of an A <sub>2</sub> 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.
49 CFR 173.475(h)	The internal pressure of the containment system will not exceed the design pressure during transportation.
49 CFR 173.475(i)	External radiation and contamination levels are within the allowable limits specified.

10 CFR 71.101-71.137	Each licensee involved with designing, purchasing, fabricating, handling, shipping, storing, cleaning, assembling, inspecting, operating, maintaining, repairing or modifying an NRC approved packaging must establish, maintain and execute a quality assurance program meeting the requirements described in 10 CFR 71 Subpart H.
	<b>Advance Notification</b>
10 CFR 71.97	10 CFR 71.97 contains requirements for advance notification of shipments of irradiated reactor fuel and nuclear waste.
	<b>Physical Protection</b>
10 CFR 73.37	10 CFR 73.37 contains the requirements for physical protection of irradiated reactor fuel in transit. This applies to shipments of greater than 100 grams of irradiated reactor fuel with a dose rate in excess of 1 Gy (100 rad) per hour at a distance of 1 meter from any accessible surface without intervening shielding. See also <i>Physical Protection of Shipments of Irradiated Nuclear Fuel</i> , NUREG-0561, Revision 2 (2013).
10 CFR 73.35	10 CFR 73.35 contains the requirements for physical protection of irradiated reactor fuel in transit. This applies to shipments of less than 100 grams of irradiated reactor fuel with a dose rate in excess of 1 Gy (100 rad) per hour at a distance of 1 meter from any accessible surface without intervening shielding.
10 CFR 73.20, 73.25, 73.26, and 73.27	If the dose rate is less than 1 Gy (100 rad) per hour at a distance of 1 meter from any accessible surface without intervening shielding and the mass of U-233, U-235, and plutonium exceeds a formula quantity (see definition in 10 CFR 73.2) is exceeded, then the requirements of 10 CFR 73.20, 73.25, 73.26, and 73.27 apply.
10 CFR 73.67	Lesser physical protection requirements apply to special nuclear material of moderate strategic significance (Category II, see definition in 10 CFR 73.2) and of low strategic significance (Category III, see definition in 10 CFR 73.2).
10 CFR 73.72	Contains requirements for advance notice of shipment of formula quantities of strategic special nuclear material, special nuclear material of moderate strategic significance, or irradiated reactor fuel.
33 CFR 6	Contains USCG requirements for the protection and security of vessels, harbors, and waterfront facilities.
33 CFR 165	33 CFR 165 allows the USCG to establish Regulated Navigation Areas (RNA) and Limited Access Areas. RNAs are water areas within a defined boundary for which regulations for vessels navigating within the area have been established. RNAs usually prescribe what type or size of vessels may enter an area or in what manner they must navigate. Limited access areas consist of safety zones, security zones, and restricted waterfront areas. The USCG has established safety and/or security zones at many nuclear power plants.
33 CFR 101, 103-106	33 CFR Parts 101 and 103-106 also contain detailed maritime security requirements.

## 7.2 Fissile Radioactive Material Schedule

Citation	Requirement
	<b>1. MATERIALS</b>
49 CFR 173.401 10 CFR 71.4	(a) Fissile material means plutonium-239, plutonium-241, uranium-233, uranium-235, or any combination of these radionuclides. Fissile material means the fissile nuclides themselves, not material containing fissile nuclides, but does not include: Unirradiated natural uranium or depleted uranium; and natural uranium or depleted uranium that has been irradiated in thermal reactors only. Certain exceptions for fissile materials are provided in 49 CFR 173.453 and 10 CFR 71.15
49 CFR 173.453 10 CFR 71.15	(b) Fissile material exceptions. This section lists 6 exceptions for small amounts (< 15 g), low concentrations, or low enrichments of fissile material.
	<b>2. PACKAGING/PACKAGE</b>
49 CFR 173.403 10 CFR 71.4	(a) “Fissile material package” means a packaging, together with its fissile material contents, which meets the requirements for fissile material packages described in subpart E of 10 CFR 71. A fissile material package may be a Type AF package, a Type B(U)F package, or a Type B(M)F package.
49 CFR 173.403 10 CFR 71.4	(b) Criticality Safety Index (CSI) means a number (rounded up to the next tenth) which is used to provide control over the accumulation of packages, overpacks or freight containers containing fissile material. The CSI for a package containing fissile material is determined in accordance with the instructions provided in 10 CFR 71.22, 71.23, and 71.59. The CSI for an overpack, freight container, consignment or conveyance containing fissile material packages is the arithmetic sum of the criticality safety indices of all the fissile material packages contained within the overpack, freight container, consignment or conveyance.
49 CFR 173.403	(c) Transport index (TI) means the dimensionless number (rounded up to the next tenth) placed on the label of a package, to designate the degree of control to be exercised by the carrier during transportation. The transport index is determined by multiplying the maximum radiation level in millisieverts (mSv) per hour at 1 m (3.3 ft) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at 1 m (3.3 ft)).
49 CFR 173.417	(d) Authorized fissile materials packages. (a) Except as provided in 49 CFR 173.453, fissile materials containing not more than A <sub>1</sub> or A <sub>2</sub> as appropriate, must be packaged in one of the following packagings: (1)(i) Any packaging listed in 49 CFR 173.415, limited to the Class 7 (radioactive) materials specified in 10 CFR 71, subpart C; (ii) Any Type AF, Type B(U)F, or Type B(M)F packaging that meets the applicable standards for fissile material packages in 10 CFR 71; or (b) Fissile Class 7 (radioactive) materials with radioactive content exceeding A <sub>1</sub> or A <sub>2</sub> must be packaged in one of the following packagings:

Citation	Requirement
	<p>(1) Type B(U), or Type B(M) packaging that meets the standards for packaging of fissile materials in 10 CFR 71, and is approved by the U.S. Nuclear Regulatory Commission and used in accordance with 49 CFR 173.471;</p> <p>(c) A package approved by the U.S. Nuclear Regulatory Commission under a special package authorization granted in accordance with 10 CFR 71.41(d) provided it is offered only for domestic transportation in accordance with the requirements in 49 CFR 173.471(b) and (c).</p>
49 CFR 173.467	<p>(e) 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.</p>
49 CFR 173.471	<p>(f) Requirements for U.S. Nuclear Regulatory Commission approved packages. In addition to the applicable requirements of the U.S. Nuclear Regulatory Commission (NRC) and other requirements of this subchapter, any offeror of a Type B(U), Type B(M), or fissile material package that has been approved by the NRC in accordance with 10 CFR Part 71 must also comply with the following requirements:</p> <p>(a) The offeror shall be registered with the USNRC as a party to the packaging approval, and make the shipment in compliance with the terms of the packaging approval;</p> <p>(b) The outside of each package must be durably and legibly marked with the package identification marking indicated in the USNRC packaging approval;</p> <p>(c) Each shipping paper related to the shipment of the package must bear the package identification marking indicated in the USNRC packaging approval.</p>
10 CFR 71.17	<p>(g) For a Type B or fissile material package, the design of which was approved by NRC before April 1, 1996, the general license is subject to the additional restrictions of 10 CFR 71.19.</p>
10 CFR 71.19	<p>(h) 10 CFR 71.19 lists the conditions under which a previously approved Type B(U), Type B(M) or fissile material package without and without the “-85” designation may be used.</p>
10 CFR 71.22	<p>(i) 10 CFR 71.22 lists the conditions under which a general license is issued to transport fissile material. The fissile material need not be contained in a package which meets the standards in 10 CFR 71, Subpart E and F; however, the material must be contained in a Type A package. The Type A package must also meet the DOT requirements of 49 CFR 173.417(a).</p>
10 CFR 71.35(b) and (c)	<p>(j) (b) For a fissile material package, the allowable number of packages that may be transported in the same vehicle in accordance with 10 CFR 71.59; and (c) For a fissile material shipment, any proposed special controls and precautions for transport, loading, unloading, and handling and any proposed special controls in case of an accident or delay.</p>
	<p><b>3. MAXIMUM RADIATION LEVELS</b></p>
	<p>See Common Provisions.</p>



Citation	Requirement
	<b>4. CONTAMINATION</b>
	See Common Provisions.
	<b>5. DECONTAMINATION</b>
	See Common Provisions.
	<b>6. MIXED CONTENTS</b>
	See Common Provisions.
	<b>7. LOADING AND SEGREGATION</b>
	(a) See Common Provisions.
	<b>Loading and Segregation: General</b>
49 CFR 173.459	(b) Mixing of fissile material packages with non-fissile or fissile-excepted material packages. Mixing of fissile material packages with other types of Class 7 (radioactive) materials in any conveyance or storage location is authorized only if the TI of any single package does not exceed 10, the CSI of any single package does not exceed 50, and the provisions of 49 CFR 173.441 and 49 CFR 173.457 are satisfied.
49 CFR 173.457	(c) Transportation of fissile material packages—specific requirements. (a) Packages containing fissile radioactive material which are not excepted under 49 CFR.453 must be assigned by the offeror, in accordance with their definitions in 49 CFR 173.403, a criticality safety index (CSI) and a transport index (TI). (b) Fissile material packages and conveyances transporting fissile material packages must satisfy the radiation level restrictions of 49 CFR 173.441. (c) Except for consignments under exclusive use, the CSI of any package or overpack may not exceed 50. A fissile material package with CSI greater than 50 must be transported by exclusive use. (d) For non-exclusive use shipments of fissile material packages, except on vessels, the total sum of CSI's in a freight container or on a conveyance may not exceed 50. (e) For exclusive use shipments of fissile material packages, except on vessels, the total sum of CSI's in a freight container or on a conveyance may not exceed 100. (f) Exclusive use shipments of fissile material packages must satisfy the radiation level and administrative requirements of 49 CFR 173.441(b). (g) The number of packages, overpacks and freight containers containing fissile material stored in transit in any one storage area must be so limited that the total sum of the CSI's in any group of packages, overpacks or freight containers does not exceed 50. Groups of packages shall be stored so as to maintain a spacing of a least 6 m (20 ft) between the closest surfaces of any two groups. (h) Provisions for shipment by vessel of Class 7 (radioactive) material packages, including fissile material packages by vessel are described in 49 CFR 176.700-176.720.

Citation	Requirement
	<b>Loading and Segregation: Railroad</b>
49 CFR 174.700(b)	(a) The number of packages of Class 7 (radioactive) materials that may be transported by rail car or stored at any single location is limited to a total transport index and a total criticality safety index (as defined in 49 CFR 173.403) of not more than 50 each. This provision does not apply to exclusive use shipments as described in 49 CFR 173.403, 173.427, 173.441, and 173.457.
49 CFR 174.700(d)	(b) Each shipment of fissile material packages must conform to requirements of 49 CFR 173.457 and 173.459.
	<b>Loading and Segregation: Highway</b>
49 CFR 177.842(f)	(a) The number of packages of fissile Class 7 (radioactive) material in any non-exclusive use transport vehicle must be limited so that the sum of the criticality safety indices (CSIs) does not exceed 50. In loading and storage areas, fissile material packages must be grouped so that the sum of CSIs in any one group is not greater than 50; there may be more than one group of fissile material packages in a loading or storage area, so long as each group is at least 6 m (20 feet) away from all other such groups. All pertinent requirements of 49 CFR 173.457 and 173.459 apply.
49 CFR 177.842(g)	(b) The sum of criticality safety indices (CSIs) for packages containing fissile material may not exceed 100 in an exclusive use vehicle.
	<b>Loading and Segregation: Aircraft</b>
49 CFR 175.700 (a)	(a) A vented Type B(M) package or liquid pyrophoric Class 7 (radioactive) material may not be carried aboard any aircraft.
49 CFR 175.700 (b)	(b) Limits for transport index and criticality safety index. A person may carry the following Class 7 (radioactive) materials aboard an aircraft only when— (2) On a cargo aircraft— (i) Each single package on the aircraft has a transport index no greater than 10.0. (ii) The combined transport index of all the packages on the aircraft is no greater than 200, and the combined criticality index of all the packages on the aircraft is no greater than— (A) 50 on a non-exclusive use cargo aircraft, or (B) 100 on an aircraft assigned for the exclusive use of the shipper [offeror] for the specific shipment of fissile Class 7 material. Instructions for the exclusive use must be developed by the shipper [offeror] and carrier, and the instructions must accompany the shipping papers. (3) The combined transport index and combined criticality index are determined by adding together the transport index and criticality index numbers, respectively, shown on the labels of the individual packages.
49 CFR 175.702(b)	(c) In addition to the limits on combined criticality safety indexes stated in 49 CFR 175.700(b), (1) The criticality safety index of any single group of packages must not exceed 50.0 (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 m (20 feet) or

Citation	Requirement
	less); and (2) Each group of packages must be separated from every other group in the aircraft by not less than 6 m (20 feet), measured from the outer surface of each group.
49 CFR 175.703(b)	(d) Each shipment of fissile material packages must conform to the requirements of 49 CFR 173.457 and 173.459.
49 CFR 175.704	(e) Plutonium shipments. Shipments of plutonium which are subject to 10 CFR 71.88(a)(4) must comply with the following: (a) Each package containing plutonium must be secured and restrained to prevent shifting under normal conditions. (b) A package of plutonium having a gross mass less than 40 kg (88 pounds) and both its height and diameter less than 50 cm (19.7 inches)— (1) May not be transported aboard an aircraft carrying other cargo required to bear a Division 1.1 label; and (2) Must be stowed aboard the aircraft on the main deck or the lower cargo compartment in the aft-most location that is possible for cargo of its size and weight, and no other cargo may be stowed aft of packages containing plutonium. (c) A package of plutonium exceeding the size and weight limitations in paragraph (b) of this section— (1) May not be transported aboard an aircraft carrying other cargo required to bear any of the following labels: Class 1 (all Divisions), Class 2 (all Divisions), Class 3, Class 4 (all Divisions), Class 5 (all Divisions), or Class 8; and (2) Must be securely cradled and tied down to the main deck of the aircraft in a manner that restrains the package against the following internal forces acting separately relative to the deck of the aircraft; Upward, 2g; Forward, 9g; Sideward, 1.5g; Downward, 4.5g.
	<b>Loading and Segregation: Water Vessel</b>
49 CFR 176.704(d)	(a) The sum of the criticality safety indices (CSI's) for all packages and overpacks of fissile Class 7 (radioactive) materials on board a vessel may not exceed the limits specified in Table IIIB of 49 CFR 176.704.
49 CFR 176.704(e)	(b) Each group of fissile Class 7 (radioactive) material packages and overpacks, containing a sum of CSIs no greater than 50 for a non-exclusive use shipment, or no greater than 100 for an exclusive use shipment, must be separated from all other groups containing fissile material packages and overpacks by a distance of at least 6 m (20 ft) at all times.
49 CFR 176.704(f)	(c) The limitations specified in paragraphs (a) through (c) of 49 CFR 176.704 do not apply when the entire vessel is reserved or chartered for use by a single offeror under exclusive use conditions if— (1) The number of packages of fissile Class 7 (radioactive) material satisfies the individual package CSI limits of 49 CFR 173.457, except that the total sums of CSI's in the last column of Table IIIB of 49 CFR 176.704, including table note (d) apply; (2) A radiation protection program for the shipment has been established and approved by the competent authority of the flag state of the vessel and, when requested, by the competent authority at each port of call; (3) Stowage arrangements have been predetermined for the whole voyage, including any consignments to be loaded at ports of call;

Citation	Requirement
	(4) The loading, transport and unloading are to be supervised by persons qualified in the transport of radioactive material; and (5) The entire shipment operation is approved by the Associate Administrator in advance.

Type of freight container or conveyance	Limit on total sum of criticality safety indices in a single freight container or aboard a conveyance	
	Not under exclusive use	Under exclusive use
I. Freight container—small	50	NA
II. Freight container—large	50	100
III. Vessel		
1. Hold, compartment or defined deck areas		
Packages, overpack, small freight containers	50	100
Large freight containers	50	100
2. Total vessel		
Packages, overpack, small freight containers	200	200
Large freight containers	No limit	No limit

NOTES:  
a For vessels, the requirements in both 1 and 2 must be fulfilled.  
b Packages or overpacks transported in or on a vehicle which are offered for transport in accordance with the provisions of 49 CFR 173.441(b) may be transported by vessels provided that they are not removed from the vehicle at any time while on board the vessel. In that case, the entries under the heading “under exclusive use” apply.  
c The consignment must be handled and stowed such that the total sum of CSIs in any group does not exceed 50, and such that each group is handled and stowed so that the groups are separated from each other by at least 6 m (20 ft).  
d The consignment must be handled and stowed such that the total sum of CSIs in any group does not exceed 100, and such that each group is handled and stowed so that the groups are separated from each other by at least 6 m (20 ft). The intervening space between groups may be occupied by other cargo.

	<b>8. MARKING AND LABELING</b>
	(a) See Common Provisions.
49 CFR 172.203 49 CFR 172.403	(b) Except for plutonium-239 and plutonium-241, the weight in grams or kilograms of fissile radionuclides (or the mass of each fissile nuclide for mixtures when appropriate) may be inserted instead of activity units. For plutonium-239 and plutonium-241, the weight in grams of fissile radionuclides (or the mass of each fissile nuclide for mixtures when appropriate) may be inserted in addition to the activity units.
49 CFR 172.203	(c) For a package containing fissile Class 7 (radioactive) material: (i) The words “Fissile Excepted” if the package is excepted pursuant to 49 CFR 173.453; or otherwise (ii) The criticality safety index for that package.

<p>49 CFR 172.402</p>	<p>(d) Each package or overpack containing fissile material, other than fissile-excepted material (see 49 CFR 173.453) must bear two FISSILE labels, affixed to opposite sides of the package or overpack, which conforms to the figure shown in 49 CFR 172.441; such labels, where applicable, must be affixed adjacent to the labels for radioactive materials.</p>
<p>49 CFR 172.403</p>	<p>(e) FISSILE label. For packages required in 49 CFR 172.402 to bear a FISSILE label, each such label must be completed with the criticality safety index (CSI) assigned in the NRC or DOE package design approval, or in the certificate of approval for special arrangement or the certificate of approval for the package design issued by the Competent Authority for import and export shipments. For overpacks and freight containers required in 49 CFR 172.402 to bear a FISSILE label, the CSI on the label must be the sum of the CSIs for all of the packages contained in the overpack or freight container.</p>
<p>49 CFR 172.403</p>	<p>(f) For fissile material, the criticality safety index which must be entered on the overpack FISSILE label is the sum of the criticality safety indices of the individual packages in the overpack, as stated in the certificate of approval for the package design issued by the NRC or the U.S. Competent Authority.</p>
<p>49 CFR 172.441</p>	<p>(g) Provides specification for FISSILE label.</p>
	<p><b>9. PLACARDING</b></p>
	<p>See Common Provisions.</p>
	<p><b>10. TRANSPORT DOCUMENTS</b></p>
	<p>See Common Provisions.</p>
	<p><b>11. STORAGE AND DISPATCH</b></p>
	<p>No specific provisions.</p>
	<p><b>12. CARRIAGE</b></p>
	<p>See Common Provisions.</p>
	<p><b>13. OTHER PROVISIONS</b></p>
	<p>See Common Provisions.</p>

### 7.3 Radioactive Material in Type B Packages Schedule

Citation	Requirement
	<b>1. MATERIALS</b>
	(a) See Common Provisions.
173.431(b)	(b) The limits on activity contained in a Type B(U) or Type B(M) package are specified in the package’s approval certificate or special package authorization.
	<b>2. PACKAGING/PACKAGE</b>
49 CFR 173.413	(a) Requirements for Type B packages. Except as provided in 49 CFR 173.416, each Type B(U) or Type B(M) package must be designed and constructed to meet the applicable requirements specified in 10 CFR Part 71.
49 CFR 173.416	(b) 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(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 49 CFR 173.471. (b) Any Type B(U) or B(M) packaging that meets the applicable requirements in “IAEA Regulations for the Safe Transport of Radioactive Material, SSR-6” (IBR, see 49 CFR 171.7 of this subchapter) and for which the foreign Competent Authority Certificate has been revalidated by DOT pursuant to 49 CFR 173.473. These packagings are authorized only for export and import shipments. (c) A package approved by the U.S. Nuclear Regulatory Commission under a special package authorization granted in accordance with 10 CFR 71.41(d) provided it is offered only for domestic transportation in accordance with the requirements in 49 CFR 173.471(b) and (c).
49 CFR 173.467	(c) 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.
49 CFR 173.471	(d) Requirements for NRC approved packages. In addition to the applicable requirements of the NRC and other requirements of this subchapter, any offeror of a Type B(U), Type B(M), or fissile material package that has been approved by the NRC in accordance with 10 CFR Part 71 must also comply with the following requirements: (a) The offeror shall be registered with the NRC 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 NRC packaging approval; (c) Each shipping paper related to the shipment of the package must bear the package identification marking indicated in the NRC packaging approval.

Citation	Requirement
10 CFR 71.17	(e) For a Type B or fissile material package, the design of which was approved by NRC before April 1, 1996, the general license is subject to the additional restrictions of 10 CFR 71.19.
10 CFR 71.19	(f) 10 CFR 71.19 lists the conditions under which a previously approved Type B(U), Type B(M) or fissile material package without and without the “-85” designation may be used.
	<b>3. MAXIMUM RADIATION LEVELS</b>
	See Common Provisions.
	<b>4. CONTAMINATION</b>
	See Common Provisions.
	<b>5. DECONTAMINATION</b>
	See Common Provisions.
	<b>6. MIXED CONTENTS</b>
	See Common Provisions.
	<b>7. LOADING AND SEGREGATION</b>
	See Common Provisions.
	<b>8. MARKING AND LABELING</b>
	(a) See Common Provisions.
49 CFR 172.310(d) 49 CFR 172, Appendix B	(b) Each Type B, Type B(U) or Type B(M) packaging must be marked on the outside of the package with the radiation trefoil symbol.
49 CFR 172.310(b)	(c) Each packaging must be marked on the outside of the package, in letters at least 12 mm (0.47 inch) high, with the words "TYPE B(U) or Type B(M)" as appropriate. A packaging which does not conform to Type B(U) or Type B(M) requirements may not be so marked.
	<b>9. PLACARDING</b>
	See Common Provisions.
	<b>10. TRANSPORT DOCUMENTS</b>
	See Common Provisions
	<b>11. STORAGE AND DISPATCH</b>

Citation	Requirement
	See Common Provisions.
	<b>12. CARRIAGE</b>
	(a) See Common Provisions.
49 CFR 175.700(a)	(b) Type B(M) packages may not be used on passenger carrying aircraft. Vented Type B(M) packages may not be carried aboard any aircraft.
	<b>13. OTHER PROVISIONS</b>
	See Common Provisions.



## 7.4 Radioactive Material Package Schedule

Citation	Requirement
49 CFR 173.410	General design requirements. In addition to the requirements of 49 CFR 173 Subparts A and B, each package used for the shipment of Class 7 (radioactive) materials must be designed so that—
49 CFR 173.410(a)	The package can be easily handled and properly secured in or on a conveyance during transport.
49 CFR 173.410(b)	Each lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.
49 CFR 173.410(c)	The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.
49 CFR 173.410(d)	The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.
49 CFR 173.410(e)	Each feature that is added to the package will not reduce the safety of the package.
49 CFR 173.410(f)	The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 49 CFR 173.24, 173.24a, and 173.24b).
49 CFR 173.410(g)	The materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.
49 CFR 173.410(h)	All valves through which the package contents could escape will be protected against unauthorized operation.
49 CFR 173.410(i)	For transport by air— (1) The temperature of the accessible surfaces of the package will not exceed 50 °C (122 °F) at an ambient temperature of 38 °C (100 °F) with no account taken for insulation; (2) The integrity of containment will not be impaired if the package is exposed to ambient temperatures ranging from -40 °C (-40 °F) to + 55 °C (131 °F); and (3) A package containing liquid contents must be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than the maximum normal operating pressure plus 95 kPa (13.8 psi).
49 CFR 173.412	Additional Design Requirements for Type A Packages. In addition to meeting the general design requirements prescribed in 49 CFR 173.410, each Type A packaging must be designed so that—

Citation	Requirement
49 CFR 173.412(a)	The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may be sealed.
49 CFR 173.412(b)	The smallest external dimension of the package is not less than 10 cm (4 inches).
49 CFR 173.412(c)	Containment and shielding is maintained during transportation and storage in a temperature range of -40 °C (-40 °F) to 70 °C (158 °F). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.
49 CFR 173.412(d)	The packaging must include a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form Class 7 (radioactive) material, as demonstrated in accordance with 49 CFR 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.
49 CFR 173.412(e)	For each component of the containment system account is taken, where applicable, of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis.
49 CFR 173.412(f)	The containment system will retain its radioactive contents under the reduction of ambient pressure to 60 kPa (8.7 psia).
49 CFR 173.412(g)	Each valve, other than a pressure relief device, is provided with an enclosure to retain any leakage.
49 CFR 173.412(h)	Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield.
49 CFR 173.412(i)	Failure of any tie-down attachment that is a structural part of the packaging, under both normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.
49 CFR 173.412(j)	When evaluated against the performance requirements of this section and the tests specified in 49 CFR 173.465 or using any of the methods authorized 49 CFR 173.461(a), the packaging will prevent— (1) Loss or dispersal of the radioactive contents; and (2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.
49 CFR 173.412(k)	Each packaging designed for liquids will— (1) Be designed to provide for ullage to accommodate variations in temperature of the contents, dynamic effects and filling dynamics; (2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in 49 CFR 173.466 or evaluated against these tests by any of the methods authorized by 49 CFR 173.461(a); and (3) Either— (i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or (ii) Have a containment system composed of primary inner and secondary outer containment components designed to enclose the liquid contents completely and ensure retention of the

Citation	Requirement
	liquid within the secondary outer component in the event that the primary inner component leaks.
49 CFR 173.412(l)	Each package designed for gases, other than tritium not exceeding 40 TBq (1080 Ci) 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 49 CFR 173.466 or evaluated against these tests by any of the methods authorized by 49 CFR 173.461(a).
49 CFR 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:
49 CFR 173.415(a)	<p>DOT Specification 7A (see 49 CFR 178.350) Type A general packaging. Until January 1, 2017 each offeror of a Specification 7A package must maintain on file for at least one year after the latest shipment, and shall provide to DOT on request, complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with that specification. After January 1, 2017 each offeror of a Specification 7A package must maintain on file for at least two years after the offeror's latest shipment, and shall provide to DOT on request, one of the following:</p> <p>(1) A description of the package showing materials of construction, dimensions, weight, closure and closure materials (including gaskets, tape, etc.) of each item of the containment system, shielding and packing materials used in normal transportation, and the following:</p> <p>(i) If the packaging is subjected to the physical tests of 49 CFR 173.465, and if applicable, 49 CFR 173.466, documentation of testing, including date, place of test, signature of testers, a detailed description of each test performed including equipment used, and the damage to each item of the containment system resulting from the tests, or</p> <p>(ii) For any other demonstration of compliance with tests authorized in 49 CFR 173.461, a detailed analysis which shows that, for the contents being shipped, the package meets the pertinent design and performance requirements for a DOT 7A Type A specification package.</p> <p>(2) If the offeror has obtained the packaging from another person who meets the definition of "packaging manufacturer" in 49 CFR 178.350(c) of this subchapter, a certification from the packaging manufacturer that the package meets all the requirements of 49 CFR 178.350 for the radioactive contents presented for transport and a copy of documents maintained by the packaging manufacturer that meet the requirements of paragraph (a)(1) of this section.</p>
49 CFR 173.415(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 49 CFR 173.471.
49 CFR 173.415(c)	Any Type B(U) or Type B(M) packaging authorized pursuant to 49 CFR 173.416.
49 CFR 173.415(d)	Any foreign-made packaging that meets the standards in the "IAEA Regulations for the Safe Transport of Radioactive Material, SSR-6" (IBR, see 49 CFR 171.7) and bears the marking "Type A". Such packagings may be used for domestic and export shipments of Class 7 (radioactive) materials provided the offeror obtains the applicable documentation of tests and engineering evaluations and maintains the documentation on file in accordance with paragraph (a) of this section. These packagings must conform with requirements of the country of origin (as indicated by the packaging marking) and the IAEA regulations applicable to Type A packagings.
49 CFR 173.418	Authorized Packages— Pyrophoric Class 7 (Radioactive) Materials. Pyrophoric Class 7 (radioactive) materials, as referenced in the 49 CFR 172.101 table of this subchapter, in quantities not exceeding $A_2$ per package must be transported in DOT Specification 7A packagings constructed of materials that will not react with, nor be decomposed by, the contents. Contents of the package must be—
49 CFR 173.418(a)	In solid form and must not be fissile unless excepted by 49 CFR 173.453;

Citation	Requirement
49 CFR 173.418(b)	Contained in sealed and corrosion resistant receptacles with positive closures (friction or slip-fit covers or stoppers are not authorized);
49 CFR 173.418(c)	Free of water and contaminants that would increase the reactivity of the material; and
49 CFR 173.418(d)	Inerted to prevent self-ignition during transport by either— (1) Mixing with large volumes of inerting materials, such as graphite, dry sand, or other suitable inerting material, or blended into a matrix of hardened concrete; or (2) Filling the innermost receptacle with an appropriate inert gas or liquid.
49 CFR 173.418(e)	Pyrophoric Class 7 (radioactive) materials transported by aircraft must be packaged in Type B packages.
49 CFR 173.419	Authorized Packages—Oxidizing Class 7 (Radioactive) Materials
49 CFR 173.419(a)	An oxidizing Class 7 (radioactive) material, as referenced in the 49 CFR 172.101 table of this subchapter, is authorized in quantities not exceeding an A <sub>2</sub> per package, in a DOT Specification 7A package provided that— (1) The contents are: (i) Not fissile; (ii) Packed in inside packagings of glass, metal or compatible plastic; and (iii) Cushioned with a material that will not react with the contents; and (2) The outside packaging is made of wood, metal, or plastic.
49 CFR 173.419(b)	The package must be capable of meeting the applicable test requirements of 49 CFR 173.465 without leakage of contents.
49 CFR 173.419(c)	For shipment by air, the maximum quantity in any package may not exceed 11.3 kg (25 pounds).
	Demonstration of compliance
10 CFR 71.41(a)	The effects on a package of the tests specified in 10 CFR 71.71 (“Normal conditions of transport”), and the tests specified in 10 CFR 71.73 (“Hypothetical accident conditions”), and 10 CFR 71.61 (“Special requirements for Type B packages containing more than 105 A <sub>2</sub> ”), must be evaluated by subjecting a specimen or scale model to a specific test, or by another method of demonstration acceptable to the Commission, as appropriate for the particular feature being considered.
10 CFR 71.41(b)	Taking into account the type of vehicle, the method of securing or attaching the package, and the controls to be exercised by the shipper, the Commission may permit the shipment to be evaluated together with the transporting vehicle.
10 CFR 71.41(c)	Environmental and test conditions different from those specified in 10 CFR 71.71 and 10 CFR 71.73 may be approved by the Commission if the controls proposed to be exercised by the shipper are demonstrated to be adequate to provide equivalent safety of the shipment.
10 CFR 71.41(d)	Packages for which compliance with the other provisions of these regulations is impracticable shall not be transported except under special package authorization. Provided the applicant demonstrates that compliance with the other provisions of the regulations is impracticable and that the requisite standards of safety established by these regulations have been demonstrated through means alternative to the other provisions, a special package authorization may be approved for one-time shipments. The applicant shall demonstrate that the overall level of safety in transport for these shipments is at least equivalent to that which would be provided if all the applicable requirements had been met.

Citation	Requirement
	General standards for all packages
10 CFR 71.43(a)	The smallest overall dimension of a package may not be less than 4 in.
10 CFR 71.43(b)	The outside of a package must incorporate a feature, such as a seal, that is not readily breakable and that, while intact, would be evidence that the package has not been opened by unauthorized persons.
10 CFR 71.43(c)	Each package must include a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by a pressure that may arise within the package.
10 CFR 71.43(d)	A package must be made of materials and construction that assure that there will be no significant chemical, galvanic, or other reaction among the packaging components, among package contents, or between the packaging components and the package contents, including possible reaction resulting from inleakage of water, to the maximum credible extent. Account must be taken of the behavior of materials under irradiation.
10 CFR 71.43(e)	A package valve or other device, the failure of which would allow radioactive contents to escape, must be protected against unauthorized operation and, except for a pressure relief device, must be provided with an enclosure to retain any leakage.
10 CFR 71.43(f)	A package must be designed, constructed, and prepared for shipment so that under the tests specified in 10 CFR 71.71 there would be no loss or dispersal of radioactive contents, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the packaging.
10 CFR 71.43(g)	A package must be designed, constructed, and prepared for transport so that in still air at 100 °F and in the shade, no accessible surface of a package would have a temperature exceeding 122 °F in a nonexclusive use shipment, or 185 °F in an exclusive use shipment.
10 CFR 71.43(h)	A package may not incorporate a feature intended to allow continuous venting during transport.
	Normal conditions of transport
71.71(a)	Evaluation. Separate packages may be used for the free drop test, compression test, and penetration test, if each package is subjected to the water spray test before being subjected to any of the other tests.
10 CFR 71.71(b)	Initial conditions. Based on ambient temperature preceding and following the tests remaining constant at that value between -20 °F and 100 °F which is most unfavorable for the feature under consideration. Initial internal pressure within the containment system must be considered to be the maximum normal operating pressure, unless a lower internal pressure consistent with the ambient temperature considered to precede and follow the tests is more unfavorable.
10 CFR 71.71(c)	Conditions and tests
10 CFR 71.71(c)(1)	Heat. Ambient temperature of 100 °F in still air and insolation.
10 CFR 71.71(c)(2)	Cold. Ambient temperature of -40 °F in still air and shade.

Citation	Requirement
10 CFR 71.71(c)(3)	Reduced external pressure. An external pressure of 3.5 lbf/in <sup>2</sup> absolute.
10 CFR 71.71(c)(4)	Increased external pressure. An external pressure of 20 lbf/in <sup>2</sup> absolute.
10 CFR 71.71(c)(5)	Vibration. Vibration normally incident to transport.
10 CFR 71.71(c)(6)	Water spray. A water spray that simulates exposure to rainfall of approximately 2 in. per hour for at least 1 hour.
10 CFR 71.71(c)(7)	Free drop. Between 1.5 and 2.5 hours after the conclusion of the water spray test, a free drop onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected. Note the distance of the drop is a function of weight.
10 CFR 71.71(c)(8)	<p>Corner drop. A free drop onto each corner of the package in succession from a height of 1 ft onto a flat, essentially unyielding, horizontal surface. Note that for a cylindrical package, the free drop would be onto each quarter of each rim.</p> <p>Note this test only applies to fiberboard, wood, or fissile material rectangular packages not exceeding 110 lb and fiberboard, wood, or fissile material cylindrical packages not exceeding 220 lb.</p>
10 CFR 71.71(c)(9)	<p>Compression. The package is subjected for a period of 24 hours to a compressive load applied uniformly to the top and bottom of the package in the position the package would normally be transported. The compressive load is the greater of 5 times the weight of the package or the equivalent of 2 lbf/in<sup>2</sup> multiplied by the vertically projected area of the package.</p> <p>Note this test is applicable for packages weighing up to 11,000 lb.</p>
10 CFR 71.71(c)(10)	Penetration. Impact of the hemispherical end of a vertical steel cylinder of 1.25 in. diameter and 13 lb mass dropped from a height of 40 in. onto the surface of the package that is expected to be the most vulnerable to puncture.
	Hypothetical accident conditions
10 CFR 71.73(a)	Test procedures. Based on sequential application of the tests, in the order indicated, to determine their cumulative effect on a package or array of packages. An undamaged specimen may be used for the water immersion tests specified in 10 CFR 71.73(c)(6).
10 CFR 71.73(b)	Test conditions. Initial conditions for the tests, except for the water immersion tests, the ambient air temperature before and after the tests must remain constant at that value between -20 °F and 100 °F which is most unfavorable for the features under consideration. Initial internal pressure within the containment system must be the maximum normal operating pressure, unless a lower internal pressure, consistent with the ambient temperature considered to precede and follow the tests, is more unfavorable.
10 CFR 71.3(c)	Tests.
10 CFR 71.73(c)(1)	Free drop. A free drop of a package through a distance of 30 ft onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected.

Citation	Requirement
10 CFR 71.73(c)(2)	<p>Crush. A crush test on a flat, essentially unyielding horizontal surface so as to suffer maximum damage by the drop of a 1100 lb mass from 30 ft onto the package. The mass must consist of a solid mild steel plate 40 in. by 40 in. and must fall in a horizontal attitude.</p> <ul style="list-style-type: none"> <li>The crush test is only required when the package has a mass not greater than 1100 lb, an overall density not greater than 62.4 lb/ft<sup>3</sup> based on external dimension, and radioactive contents greater than 1000 A<sub>2</sub> not as special form radioactive material.</li> </ul> <p>Note for packages containing fissile material, the radioactive contents greater than 1000 A<sub>2</sub> criterion does not apply.</p>
10 CFR 71.73(c)(3)	<p>Puncture. A free drop of the package through a distance of 40 in. in the position for which maximum damaged is expected onto the upper end of a solid, vertical, cylindrical, mild steel bar mounted onto an essentially unyielding, horizontal surface. The bar must be 6 in. in diameter and have a length as to cause maximum damage to the package, but not less than 8 in. long.</p>
10 CFR 71.73(c)(4)	<p>Thermal. Exposure of the package fully engulfed in a hydrocarbon fuel/air fire with an average flame temperature of at least 1475 °F for a period of 30 minutes.</p>
10 CFR 71.73(c)(5)	<p>Immersion – fissile material For fissile material subject to 10 CFR 71.55, in cases where water inleakage has not been assumed for criticality analyses, immersion under a head of water of at least 3 ft in the attitude for which maximum leakage is expected.</p>
10 CFR 71.73(c)(6)	<p>Immersion – all packages. A separate, undamaged package subjected to water pressure equivalent to immersion under a head of water of at least 50 ft.</p>
	<p>Additional requirements for Type B packages</p>
10 CFR 71.51(a)(1)	<p>There would be no loss or dispersal of radioactive contents--as demonstrated to a sensitivity of 10<sup>-6</sup> A<sub>2</sub> per hour and no substantial reduction in the effectiveness of the packaging under the 10 CFR 71.71 NCT tests</p>
10 CFR 71.51(a)(2)	<p>There would be no escape of krypton-85 exceeding 10 A<sub>2</sub> in 1 week and no escape of other radioactive material exceeding a total amount A<sub>2</sub> in 1 week under the 10 CFR 71.73 HAC tests</p>
	<p>Special requirements for Type B packages containing more than 10<sup>5</sup>A<sub>2</sub></p>
10 CFR 71.61	<p>A Type B package containing more than 10<sup>5</sup> A<sub>2</sub> must be designed so that its undamaged containment system can withstand an external water pressure of 2 MPa (290 psi) for a period of not less than 1 hour without collapse, buckling, or inleakage of water.</p>
	<p>External radiation standards for all packages</p>
10 CFR 71.47(a)	<p>Except as provided in paragraph (b) of this section, each package of radioactive materials offered for transportation must be designed and prepared for shipment so that under conditions normally incident to transportation the radiation level does not exceed 2 mSv/h (200 mrem/h) at any point on the external surface of the package, and the transport index does not exceed 10.</p>
10 CFR 71.47(b)	<p>A package that exceeds the radiation level limits specified in paragraph (a) of this section must be transported by exclusive use shipment only, and the radiation levels for such shipment must not exceed the following during transportation:</p>

Citation	Requirement
	<p>(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):</p> <p>(i) The shipment is made in a closed transport vehicle;</p> <p>(ii) The package is secured within the vehicle so that its position remains fixed during transportation; and</p> <p>(iii) There are no loading or unloading operations between the beginning and end of the transportation;</p> <p>(2) 2 mSv/h (200 mrem/h) at any point on the outer surface 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</p> <p>(3) 0.1 mSv/h (10 mrem/h) at any point 2 meters (80 in) from the outer lateral surfaces of the vehicle (excluding the top and underside of the vehicle); or in the case of a flat-bed style vehicle, at any point 2 meters (6.6 feet) from the vertical planes projected by the outer edges of the vehicle (excluding the top and underside of the vehicle); and</p> <p>(4) 0.02 mSv/h (2 mrem/h) in any normally occupied space, except that this provision does not apply to private carriers, if exposed personnel under their control wear radiation dosimetry devices in conformance with 10 CFR 20.1502.</p>
10 CFR 71.47(c)	For shipments made under the provisions of paragraph (b) of this section, the shipper shall provide specific written instructions to the carrier for maintenance of the exclusive use shipment controls. The instructions must be included with the shipping paper information.
10 CFR 71.47(d)	The written instructions required for exclusive use shipments must be sufficient so that, when followed, they will cause the carrier to avoid actions that will unnecessarily delay delivery or unnecessarily result in increased radiation levels or radiation exposures to transport workers or members of the general public.
10 CFR 71.55	General Requirements for Fissile Material Packages
10 CFR 71.55(b)	<p>Package must remain subcritical if water were to leak into the containment system or liquid contents were to leak out under the following conditions.</p> <ul style="list-style-type: none"> <li>• 10 CFR 71.55(b)(1) Fissile material in most reactive credible configuration consistent with chemical and physical form of the material;</li> <li>• 10 CFR 71.55(b)(2) Moderation by water to the most reactive credible extent; and</li> <li>• 10 CFR 71.55(b)(3) With close full reflection of the containment system by water on all sides, or such greater reflection of the containment system as may additionally be provided by the surrounding material of the packaging.</li> </ul>
10 CFR 71.55(c)	The Commission may approve exceptions to the requirements of 10 CFR 71.55(b) of this section if the package incorporates special design features that ensure that no single packaging error would permit leakage, and if appropriate measures are taken before each shipment to ensure that the containment system does not leak.
10 CFR 71.55(d)	Package must remain subcritical under tests specified in 10 CFR 71.71 (NCT) and must ensure that:



Citation	Requirement
	<ul style="list-style-type: none"> <li>• 10 CFR 71.55(d)(2) The geometric form of the package contents would not be substantially altered;</li> <li>• 10 CFR 71.55(d)(3) There would be no leakage of water into the containment; and</li> <li>• 10 CFR 71.55(d)(4) There would be no substantial reduction in the effectiveness of the packaging including:                             <ul style="list-style-type: none"> <li>○ No more than 5 percent reduction in the total effective volume of the packaging on which nuclear safety is assessed;</li> <li>○ No more than 5 percent reduction in the effective spacing between the fissile contents and the outer surface of the packaging; and</li> </ul> </li> </ul> <p>No occurrence of an aperture in the outer surface of the packaging large enough to permit the entry of a 10 cm (4 in.) cube.</p>
10 CFR 71.55(e)	<p>Package must remain subcritical under tests specified in 10 CFR 71.73 (HAC)</p> <ul style="list-style-type: none"> <li>• 10 CFR 71.55(e)(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents</li> <li>• 10 CFR 71.55(e)(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents</li> </ul> <p>10 CFR 71.55(e)(3) There is full reflection by water on all sides, as close as is consistent with the damaged condition of the package.</p>
	Requirements for fissile material packages transported by air
10 CFR 71.55(f)(1)	<p>The package must be designed and constructed, and its contents limited so that it would be subcritical, assuming reflection by 20 cm (7.9 in) of water but no water inleakage, when subjected to sequential application of:</p> <ul style="list-style-type: none"> <li>• 10 CFR 71.55(f)(1)(i) The free drop test in 10 CFR 71.73(c)(1)</li> <li>• 10 CFR 71.55(f)(1)(ii) The crush test in 10 CFR 71.73(c)(2)</li> <li>• 10 CFR 71.55(f)(1)(iii) A puncture test (for packages of 250 kg or more)</li> <li>• 10 CFR 71.55(f)(1)(iv) The thermal test in 10 CFR 71.73(c)(4), except that the duration of the test must be 60 minutes</li> </ul>
10 CFR 71.55(f)(2)	<p>The package must be designed and constructed, and its contents limited, so that it would be subcritical, assuming reflection by 20 cm (7.9 in) of water but no water inleakage, when subjected to an impact on an unyielding surface at a velocity of 90 m/s normal to the surface, at such orientation so as to result in maximum damage. A separate, undamaged specimen can be used for this evaluation.</p>
	Standards for arrays of fissile material packages

Citation	Requirement
10 CFR 71.59(a)	The package must be controlled during transport to assure that an array of such packages remains subcritical.
	Special requirement for plutonium shipments
10 CFR 71.63	Shipments containing plutonium must be made with the contents in solid form, if the contents contain greater than 0.74 TBq (20 Ci) of plutonium.
	Special requirements for plutonium air shipments
10 CFR 71.64(a)	A package for the shipment of plutonium by air, in addition to satisfying the requirements above, must be designed, constructed, and prepared for shipment so that under the tests specified in:
10 CFR 71.64(a)(1)	10 CFR 71.74, Accident conditions for air transport of plutonium
10 CFR 71.64(a)(1)(i)	The containment vessel would not be ruptured in its post-tested condition, and the package must provide a sufficient degree of containment to restrict accumulated loss of plutonium contents to not more than an A <sub>2</sub> quantity in a period of 1 week
10 CFR 71.64(a)(1)(ii)	The external radiation level would not exceed 10 mSv/h (1 rem/h) at a distance of 1 m (40 in.) from the surface of the package in its post-tested condition in air
10 CFR 71.64(a)(1)(iii)	A single package and an array of packages are demonstrated to be subcritical in accordance with this part, except that the damaged condition of the package must be considered to be that which results from the plutonium accident tests in 10 CFR 71.74, rather than the hypothetical accident tests in 10 CFR 71.73
10 CFR 71.64(a)(2)	After the tests in Section 10 CFR 71.74(c) there would be no detectable leakage of water into the containment vessel of the package
10 CFR 71.64(b)	With respect to the package requirements of paragraph 10 CFR 71.64(a), there must be a demonstration or analytical assessment showing that—
10 CFR 71.64(b)(1)	The results of the physical testing for package qualification would not be adversely affected to a significant extent by:
10 CFR 71.64(b)(1)(i)	The presence, during the tests, of the actual contents that will be transported in the package; and
10 CFR 71.64(b)(1)(ii)	Ambient water temperatures ranging from 0.6 °C ( + 33 °F) to 38 °C ( + 100 °F) for those qualification tests involving water, and ambient atmospheric temperatures ranging from -40 °C (-40 °F) to + 54 °C ( + 130°F) for the other qualification tests
10 CFR 71.64(b)(2)	The ability of the package to meet the acceptance standards prescribed for the accident condition sequential tests would not be adversely affected if one or more tests in the sequence were deleted
	Accident conditions for air transport of plutonium
10 CFR 71.74(a)	Test conditions—Sequence of tests. A package must be physically tested to the following conditions in the order indicated to determine their cumulative effect.

Citation	Requirement
71.74(a)(1)	Impact at a velocity of not less than 129 m/sec (422 ft/sec) at a right angle onto a flat, essentially unyielding, horizontal surface, in the orientation (e.g., side, end, corner) expected to result in maximum damage at the conclusion of the test sequence.
10 CFR 71.74(a)(2)	A static compressive load of 31,800 kg (70,000 lb) applied in the orientation expected to result in maximum damage at the conclusion of the test sequence. The force on the package must be developed between a flat steel surface and a 5 cm (2 in.) wide, straight, solid, steel bar. The length of the bar must be at least as long as the diameter of the package, and the longitudinal axis of the bar must be parallel to the plane of the flat surface. The load must be applied to the bar in a manner that prevents any members or devices used to support the bar from contacting the package.
10 CFR 71.74(a)(3)	Packages weighing less than 227 kg (500 lb) must be placed on a flat, essentially unyielding, horizontal surface, and subjected to a weight of 227 kg (500 lb) falling from a height of 3 m (10 ft) and striking in the position expected to result in maximum damage at the conclusion of the test sequence. The end of the weight contacting the package must be a solid probe made of mild steel. The probe must be the shape of the frustum of a right circular cone, 30 cm (12 in.) long, 20 cm (8 in.) in diameter at the base, and 2.5 cm (1 in.) in diameter at the end. The longitudinal axis of the probe must be perpendicular to the horizontal surface. For packages weighing 227 kg (500 lb) or more, the base of the probe must be placed on a flat, essentially unyielding horizontal surface, and the package dropped from a height of 3 m (10 ft) onto the probe, striking in the position expected to result in maximum damage at the conclusion of the test sequence.
10 CFR 71.74(a)(4)	The package must be firmly restrained and supported such that its longitudinal axis is inclined approximately 45° to the horizontal. The area of the package that made first contact with the impact surface in paragraph (a)(1) of this section must be in the lowermost position. The package must be struck at approximately the center of its vertical projection by the end of a structural steel angle section falling from a height of at least 46 m (150 ft). The angle section must be at least 1.8 m (6 ft) in length with equal legs at least 13 cm (5 in) long and 1.3 cm (0.5 in.) thick. The angle section must be guided in such a way as to fall end-on, without tumbling. The package must be rotated approximately 90° about its longitudinal axis and struck by the steel angle section falling as before.
10 CFR 71.74(a)(5)	The package must be exposed to luminous flames from a pool fire of JP-4 or JP-5 aviation fuel for a period of at least 60 minutes. The luminous flames must extend an average of at least 0.9 m (3 ft) and no more than 3 m (10 ft) beyond the package in all horizontal directions. The position and orientation of the package in relation to the fuel must be that which is expected to result in maximum damage at the conclusion of the test sequence. An alternate method of thermal testing may be substituted for this fire test, provided that the alternate test is not of shorter duration and would not result in a lower heating rate to the package. At the conclusion of the thermal test, the package must be allowed to cool naturally or must be cooled by water sprinkling, whichever is expected to result in maximum damage at the conclusion of the test sequence.
10 CFR 71.74(a)(6)	Immersion under at least 0.9 m (3 ft) of water.
10 CFR 71.74(b)	Individual free-fall impact test
10 CFR 71.74(b)(1)	An undamaged package must be physically subjected to an impact at a velocity not less than the calculated terminal free-fall velocity, at mean sea level, at a right angle onto a flat, essentially unyielding, horizontal surface, in the orientation (e.g., side, end, corner) expected to result in maximum damage.
10 CFR 71.74(b)(2)	This test is not required if the calculated terminal free-fall velocity of the package is less than 129 m/sec (422 ft/sec), or if a velocity not less than either 129 m/sec (422 ft/sec) or the

Citation	Requirement
	calculated terminal free-fall velocity of the package is used in the sequential test of paragraph (a)(1) of this section.
10 CFR 71.74(c)	Individual deep submersion test
10 CFR 71.74(c)	An undamaged package must be physically submerged and physically subjected to an external water pressure of at least 4 MPa (600 lb/in <sup>2</sup> ).

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## Appendix A – Title

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