LEGAL ASPECTS OF THE TRANSPORTATION OF NUCLEAR MATERIALS

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ABSTRACT

This paper will discuss the legal requirements pertaining to the transportation of nuclear materials in the United States. It will take the viewpoint of the shipper or transporter of materials who must comply with the applicable requirements. The goal is to provide insight as to what one must do to transport materials legally. The paper will focus on the regulations of the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission and will touch briefly on international requirements. It will cover the spectrum of nuclear materials, from sealed sources up to high-level nuclear waste and spent nuclear fuel, to provide a helpful overview of this aspect of the industry.

INTRODUCTION

Shippers and carriers of radioactive materials must be familiar with a large and complex body of regulations, promulgated by several federal agencies with overlapping regulatory authority. These regulations affect many aspects of the industry. Because of their complexity, shippers and carriers may benefit from an overview of the regulations in order to assist them in compliance and avoid potential legal difficulties in the conduct of their businesses.

SOURCES OF REGULATION

The Department of Transportation ("DOT") is the primary source of these federal regulations. DOT has regulatory responsibility for safety in the transportation of all hazardous materials, including radioactive material. This includes all intrastate, interstate, and foreign shipments, except for postal shipments, which fall under the authority of the U.S. Postal Service. DOT regulations cover all aspects of transportation, including packaging and shipper and carrier responsibilities. DOT transportation regulations for radioactive materials are found in the Code of Federal Regulations ("CFR") in 49 CFR Parts 100 to 185.

The Nuclear Regulatory Commission ("NRC") shares regulatory authority with DOT for certain nuclear materials which require an NRC license. However, NRC has delegated much of its authority to DOT pursuant to a 1979 Memorandum of Understanding to preclude conflicting and duplicative regulations. Additionally, the NRC has delegated authority to many states concerning intrastate transportation of certain types of licensed radioactive material. Existing NRC regulations, found in 10 CFR Part 71, are primarily concerned with special packaging requirements for highly radioactive materials (e.g., high-level nuclear waste).

The Postal Service will transport limited quantities of low-level radioactive materials. Postal Service regulations are found primarily in the Domestic Mail Manual (39 CFR Part 124). The manual prohibits air-mail of radioactive materials and significantly limits surface mail transportation.

A number of international organizations, many of which are affiliated with the United Nations ("UN"), draft regulations and recommend their adoption by member nations. The International Atomic Energy Agency ("IAEA") has been the primary agency proposing regulations in this field. Other organizations include the International Civil Aviation Organization, the International Air

Transport Association, and the International Maritime Organization. The U.S. Postal Service publishes the International Mail Manual which covers international mail shipments.

SCOPE OF FEDERAL REGULATIONS

Transportation regulations apply only to "radioactive materials," also known as "class 7" hazardous materials, as defined in 49 CFR § 173.403. Only materials with a specific activity greater than 70 Bq/g (0.002 μCi/g) are "radioactive materials" subject to DOT and NRC regulations. Additionally, materials that exceed this threshold specific activity in their pure form can be uniformly mixed with another substance to reduce their specific activity below the threshold level (i.e., "concentration averaged"). Materials with specific activity below the threshold are "exempt materials," which are exempt from DOT hazardous material regulations. Nevertheless, exempt materials may still be subject to NRC licensing or waste burial requirements and may be "hazardous substances" or "hazardous wastes" subject to Environmental Protection Agency (EPA) regulation.

CLASSES OF MATERIALS AND PACKAGING REQUIREMENTS

Regulatory Principles and Levels of Packaging

The purpose of the regulations for the transport of radioactive materials is to ensure the safety of transport workers, property, the environment, and the general public. To achieve this, the regulations provide for:

(a) containment of the material during handling and transport,
(b) protection of persons from the radiation emitted by the material,
(c) dissipation of any excessive heat from the radioactive decay of the material, and
(d) prevention of accidental criticality in the case of fissile material

The regulations rely primarily on shippers, through packaging requirements. There are several levels of packaging requirements which are designed commensurate with the level of hazards associated with the type, quantity, and form of the radioactive material being shipped. The packaging requirements are "performance-oriented"—the greater the risk posed by the contents of a package, the greater the package's security and tolerance for extreme conditions. Packages are also subject to various labeling, marking, placarding, shipping paper, and transportation requirements, determined by the type of package being shipped rather than its particular contents. The DOT classifications of radioactive materials and their packaging requirements are discussed below.

"Type A" and "Type B" Materials

"Type A" radioactive materials are those of limited activity or limited quantity such that an accident with them would be unlikely to result in an unacceptable level of radiation. Type A quantities of materials must be transported in Type A packages, which are designed to specified test conditions intended to simulate normal conditions of transport. Type A packages are subject to the general package design requirements of 49 CFR §§ 173.410 and 173.24, to additional requirements in sections 173.412 and 173.415, and to the testing requirements in section 173.465. Packages containing liquids or gases have more stringent requirements (§§ 173.412(k) & 173.466). Several authorized Type A packages are illustrated and explained in DOT's Radioactive Material Regulations Review, RAM-REG 01-98, at 28-29. This guide may be downloaded from DOT's website http://hazmat.dot.gov/pubtrain/ramreview.pdf.

The upper limit for activity in a Type A package depends on whether a material is in "special form" or "normal form." A special form material (defined in § 173.403) is in a physical state that would not disperse after release from its package, because of either its inherent properties or encapsulation. Thus, special form sources pose only an external radiation hazard, not a contamination hazard. Testing requirements to qualify materials as "special form" are found in section 173.469. Normal form materials (defined in § 173.403) are usually not securely encapsulated and could pose a significant contamination hazard if the package ruptured. Therefore, the special form (A_1) activity limit is considerably higher than the normal form activity limit (A_2). A table in section 173.435 lists A_1 and A_2 values for several hundred radionuclides. The regulations also prescribe the procedure for deriving A_1 and A_2 values for unlisted materials and mixtures.

Quantities of materials that exceed the activity limits for Type A materials are classified as "Type B" materials and must be transported in Type B packages. In contrast to Type A packages, which are designed to survive conditions of normal transport, Type B packages are designed to survive severe accidents such that the integrity of the package will be maintained with no loss of the contents and only a limited loss of its shielding capability. Type B packages are subject to general package design requirements (§§ 173.410 & 173.24), to the Type A requirements (§§ 173.412 & 173.415), and to rigorous Type B design requirements and performance-based tests, found in 10 CFR Part 71. Shippers of Type B packages may also be subject to advance notification requirements, such as alerting state governors that Type B packages containing licensed material such as spent nuclear fuel will be transported through their state (10 CFR §§ 71.97 & 73.72). The Radioactive Material Regulations Review describes and illustrates several typical Type B package designs (pp. 32-34).

Certain Type B packages carrying very high quantities of radioactive materials may be subject to additional regulations as Highway Route Controlled Quantities. These materials are subject to all of the Type B packaging requirements. In addition these shipments must comply with further DOT regulations specified in 49 CFR §§ 173.403 & 397.10(b), which prescribe certain highway-routing, as well as specific driver training requirements.

Industrial Packaging and LSA/SCO Materials

Low Specific Activity ("LSA") and Surface Contaminated Object ("SCO") materials, often characterized as radioactive waste, require "industrial packaging." Generally speaking, the requirements are less stringent than the full set of DOT Type A and Type B requirements. LSA materials have a relatively low concentration of radioactivity, with LSA-I material generally having the lowest and LSA-III material generally having the highest (see § 173.403 & 10 CFR § 71.4). SCO materials are nonradioactive objects with contamination on their surfaces and are either SCO-I or SCO-II (see § 173.403). Characterization of SCO materials is dependant on whether contamination is fixed or not and whether the contaminated surface is accessible or inaccessible. For guidance, see "Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects, NUREG-1608," available from the NRC. Additionally, section 173.427(a) imposes a strict radiation does rate limit for SCO or LSA material, above which one cannot use LSA or SCO packaging.

Under certain circumstances, LSA and SCO materials may be shipped in "strong tight," Type A packages, or Type B packages that prevent leakage of the contents. Certain shipments of LSA and SCO materials generally categorized as nuclear waste will be shipped in industrial packaging ("IP") packages, categorized as IP-I, IP-II, and IP-III packages. Section 173.411 and table 8 in § 173.427 set forth detailed industrial package requirements. IP-I is essentially equivalent to strong tight pack-

aging, which must meet the general packaging requirements for all radioactive materials (§§ 173.24 & 173.410). IP-II packages and IP-III packages are subject to successively more stringent requirements. SCO materials and certain LSA-II and LSA-III materials are also subject to conveyance activity limits as described in § 173.427.

Fissile Radioactive Materials

In addition to consideration of the radioactivity content, shippers of radioactive materials that are also fissile must consider additional requirements which are intended to prevent accidental nuclear criticality during transportation. Section 173.403 defines fissile material as plutonium-238, plutonium-239, plutonium-241, uranium-233, uranium-235 or any combination of these. Unirradiated natural uranium and depleted uranium, and natural uranium or depleted uranium that has been irradiated in thermal reactors, are not included in this definition. Fissile material requirements are set forth in 49 CFR § 173.417 and almost always require fissile Type A or fissile Type B packaging. The Radioactive Material Regulations Review includes descriptions and illustrations of typical fissile radioactive material packaging and describes instances where additional "fissile material controlled shipment" regulations may apply (pp. 36-38).

Exempted and Excepted Materials

"Exempted" materials, as described above, do not fall within the definition of radioactive materials for purposes of the transportation regulations. These materials are exempted from DOT packaging requirements, although they may be subject to NRC or EPA regulation.

"Excepted" packages are excepted from specific DOT labeling, marking and shipping paper requirements, but not from the regulations generally. Excepted radioactive materials include "limited quantities" (in terms of activity), certain "empty packages" containing residual radioactivity, and certain "radioactive instruments and articles," such as electron tubes and luminous watches, that pose very little radiological safety risk. Excepted material must be shipped in "strong tight" containers which must meet the general design requirements found in 49 CFR §§ 173.410 and 173.24. Sections 173.421-.426 contain specific requirements.

Shipping via U.S. Mail

Only exempted and some excepted materials may be shipped via the U.S. Mail. The Domestic Mail Manual prohibits all air mail transportation of radioactive materials and significantly limits surface mail transportation. The only categories of radioactive material that are mailable are certain limited quantities, excepted instruments, articles, and devices, and certain articles containing naturally occurring uranium and thorium. Generally, a package containing radioactive material can be mailed if it is among the categories excepted from the DOT packaging requirements and if its radioactivity is below one tenth the limits set forth in Table 7 in § 173.425. Therefore, a good "rule of thumb" regarding postal shipments of radioactive materials, is that if the package requires a DOT label, or contains more than one-tenth of the DOT limited quantity, it is not mailable.

GENERAL HAZARDOUS MATERIALS SHIPPING REQUIREMENTS

Shippers of hazardous materials, which include radioactive materials, bear the primary burden for assuring compliance with DOT's transportation requirements. Principal provisions address shipping papers, package marking, package labeling, vehicle placarding, stowage requirements, emergency response information, and employee training. Compliance with DOT's transportation regulations for

hazardous materials centers around the Hazardous Materials Table in § 172.101. These are the essential steps:

A. Identify the material by
   - proper shipping name
   - Hazard Class (radioactive materials are Class 7)
   - Identification number
   - Packing group
B. Determine authorized packaging
C. Determine proper labeling, marking, and placarding requirements
D. Determine if any restrictions or special provisions apply
E. Determine other requirements, e.g., Shipper's Certification (§ 172.204) or Emergency Response Information and Telephone Number (§§ 172.602 & -.604)
F. Determine additional air, rail or water transport limitations as appropriate
G. Determine if the material is also a hazardous substance (Table 2 to § 172.101 Appendix A for radionuclides) or a marine pollutant (§ 172.101 Appendix B)

Shipping Paper Requirements
Under sections 172.200-.205, shippers are required to include a great deal of specific information in shipping papers. The shipper must properly identify the material being shipped by name, classification, UN identification number, and activity. The shipper must also include an emergency response telephone number and must list any package certification markings required by DOT, NRC, or the Department of Energy. The Radioactive Material Regulations Review describes proper shipping paper forms and provides examples on pp. 50-52.

Unless excepted, shipping papers must also include a certification statement signed by the shipper (§ 172.204). Examples for shipments except those by air appear in §§ 172.204(a)(1) and 172.204(a)(2). Examples for air shipments appear in §§ 175.75(a)(3).

Excepted packages are exempted from the detailed shipping paper requirements. However, shipping papers are required if the excepted package is either a "hazardous substance" (§ 172.101, Appendix A) or a "hazardous waste" (§ 171.8).

Marking Requirements
Sections 172.300 to 172.338 prescribe marking requirements on packages, freight containers, and transport vehicles for hazardous materials transportation. Section 172.310 specifically applies to radioactive materials. Essentially, packages containing radioactive materials must be properly identified by UN identification number, gross weight, type of packaging, and the applicable package specification or certification identification number.

Labeling Requirements
Sections 172.400 to 172.450 prescribe package labeling requirements. Specific requirements for radioactive packages are found in § 172.403. The primary factors governing labeling are the dose rate at the surface of the package, the Transport Index ("TI"), and whether the materials constitute a Highway Route Controlled Quantity. The TI number, which must appear on the label, is the key parameter used to determine how far shipments of radioactive materials must be separated from persons

and other cargo during transport. The formula for calculating the TI number is found in its definition in § 173.403.

Placarding Requirements
Sections 172.500 to 172.560 prescribe vehicle and reusable freight container placarding requirements for all hazardous materials. Placards are diamond-shaped and color-coded by hazard class. The "Radioactive" placard is found at § 172.566. Under section 173.427(a)(6)(v), the shipper is responsible for placarding the transport vehicle with the "Radioactive" placard. The carrier is also required to placard the transport vehicle under certain circumstances, such as when the radioactive material bears the "Radioactive Yellow-III" label.

Emergency Response Information Requirements
Sections 172.600 to 172.608 prescribe the shipper's emergency response information requirements. Section 172.602 requires shippers to provide emergency response information for all nonexempted and nonexcepted shipments. The information must be kept on the transport vehicle on a shipping paper or on an associated document. The information must include the technical name and basic description of the material, immediate hazards to health, immediate precautions to be taken in the event of an accident, immediate methods of handling spills, leaks, and fires, and preliminary first aid measures. The North American Emergency Response Guidebook, which was prepared by DOT in conjunction with Canada and Mexico to be used by first responders to accidents, often contains sufficient information to satisfy section 172.602. In addition to the paper requirements, shippers are required by section 172.604 to provide an emergency response telephone number, which must be monitored on a 24-hour basis by one who is knowledgeable of mitigation information or has immediate access to such a person.

Training Requirements
Sections 172.700 to 172.704 prescribe training for employees involved in the transportation of hazardous materials to ensure that they are generally familiar with the hazardous material transportation requirements and receive safety training and function-specific training. The section provides for initial training within 90 days of employment on a specific job and recurrent training every three years or within 90 days after assignment to a new job. Each employee must be tested to determine the effectiveness of the training. Employers must certify that each employee has been properly trained and must maintain records of this certification.

Carrier-Specific Restrictions
While most DOT regulations apply to shippers of hazardous material, a few requirements are transport-specific. Transporters, or carriers, of radioactive materials must abide by general transportation requirements as well as requirements that are specific to the relevant mode of transportation. Generally, radioactive materials may not be shipped together with certain classes of explosives and may be shipped with flammable gases only with proper separation. 49 CFR §§ 174.81, 177.848, 176.83. To control the radiation level created by multiple packages, the carrier must maintain certain separation distances from other radioactive packages and from persons and/or photographic film. Package stowage restrictions are governed by the transport index sum (§ 173.403) in each vehicle or storage area group. 49 CFR Part 174 prescribes rail carrier regulations. Sections 174.700 to 174.750 prescribe radioactive materials requirements for package stowage, cleanliness of transport vehicle, and response to leaking packages. 49 CFR Part 175 prescribes air carrier regulations. Sections 175.700 to 175.705 prescribe radioactive materials requirements for package stowage, carriage, and aircraft

inspection. 49 CFR Part 176 regulates shipment by vessel. Section 176.700 to 176.715 prescribe radioactive materials requirements for stowage and package contamination control. 49 CFR Part 177 prescribes regulations for highway shipments. Sections 177.842, 177.843, and 177.870(g) are specific radioactive materials regulations.

Motor Carrier Safety Requirements
Motor carrier safety requirements are found in 49 CFR Parts 325 to 399. Drivers transporting radioactive material must have a "commercial drivers license" with a "hazardous materials" endorsement (§ 383.93). Vehicles containing radioactive material for which placarding is required must be operated on routes that minimize radiological risk (§ 397.101(a)). Vehicles containing a Highway Route Controlled Quantity may operate only over "preferred routes" (interstate highways and state-designated alternate routes). The driver must have received specific training within two years of the shipment, must possess a certificate of training, and must be provided with a written route plan .

Contamination Control
The DOT regulations prescribe certain limits for the control of removable external radioactive contamination. Table 11 in § 173.443 provides surface contamination limits for packages in shipments that are not "exclusively" for one shipper or consignor. For "exclusive use" shipments by rail or highway, the contamination level may not exceed ten times the Table 11 limit. These limits apply to all shipped packages as well as areas following cleanup of any spill during transport.

Registration Requirements
Shippers and transporters of certain hazardous materials must participate in a national registration program. (§§ 107.601-.620). For radioactive materials, only shippers and transporters of Highway Route Controlled Quantity materials or certain bulk packaging materials are subject to registration.

Quality Control Requirements
Before the first use of any packaging, the shipper must ensure that the packaging meets the quality and containment requirements of the DOT regulations (§§ 173.474-.475). Before each shipment of any radioactive material, the shipper must "ensure, by examination or appropriate tests" that the packaging is proper for the materials shipped and is in unimpaired condition.

NRC TRANSPORTATION-RELATED REGULATIONS
NRC Licensing Requirement
The NRC's transportation-related regulations apply to all shippers and carriers of NRC-licensed radioactive material (i.e., "source," "byproduct," or "special nuclear" material). All NRC licensees are required to comply with the NRC regulations (10 CFR § 71.5) as well as applicable DOT regulations. 10 CFR § 20.1906 requires that an NRC licensee who receives a radioactive package fulfill certain radiation monitoring requirements.

NRC Access-Control Requirement
10 CFR § 20.1601(c) requires control of access to areas containing radioactive material packages under certain circumstances. Control is not required if: 1) packages do not remain in the area longer than 3 days; 2) the dose rate at 1 m from the external surface of any package does not exceed 0.1 mSv/h; and 3) no package has a transport index (§ 173.403) exceeding 10.

NRC Regulations Pertaining to Low-Level Nuclear Waste
10 CFR Part 61 regulates the siting and operation of near surface low-level waste disposal sites, as well as the classification and form of any materials (typically LSA or SCO materials) which may be transported to a disposal site. (note: Part 61 Classes A & B are not synonymous with DOT Classes A & B). The "Radioactive Waste Manifest" required by the burial site operator should contain information similar to DOT shipping papers for transportation of other radioactive materials.

NRC Package Certification Requirement
Virtually all packages used for domestic shipments of Type B quantities of material and fissile material require package certification. Shipments must be in compliance with the terms of the certification. Package approval standards and performance requirements are described in 10 CFR Part 71.

NRC Carrier Requirements
Common and Contract Carriers are exempt from NRC license requirements to the extent they transport licensed radioactive material for third persons. 10 CFR §§ 30.13, 40.12 & 70.12. However all carriers are subject to applicable DOT regulations. Private Carriers must be licensed by NRC (or delegated state) to possess and transport radioactive material and must comply with DOT regulations. The NRC regulations note that carriers must assure the transport vehicle is properly placarded (49 CFR 172, Subpart F); assure the shipper has properly certified shipment (49 CFR § 172.204); maintain radiation control based on package TI/separation table and other transportation requirements; report to DOT all incidents involving fire, accident, breakage or suspected radioactive contamination (49 CFR §§ 171.15, 171.16, 174.750, 175.700(b), 176.710, and 177.861); provide training to employees involved in materials transportation (49 CFR 172, Subpart H); and register with DOT and submit an annual fee when transporting certain radioactive materials.

The NRC prescribes general inspection and certification requirements, which are essentially identical to DOT requirements (10 CFR §§ 71.85 & 71.87). 10 CFR §§ 71.101-.137 contain specific quality assurance requirements associated with the design, fabrication, and use of NRC-certified Type B and fissile material transport packages.

REQUIREMENTS FOR SHIPMENTS OF URANIUM HEXAFLUORIDE (UF_6)
DOT and NRC provide specific packaging requirements and quantity limits for UF_6. Solid UF_6 is packaged and shipped essentially as either an LSA or as a fissile material depending on its enrichment. Specific packaging requirements are found in 49 CFR § 173.420. NRC also has issued several Certificates of Compliance for UF_6 transport packages which specifically approve of their designs. Quantity limits for fissile UF_6 as residual "heels" of material in empty cylinders are found in § 173.417(a)(7). Quantity limits for fissile UF_6 found in metal cylinders overpacked in special DOT overpacks are found in section 173.417(b)(5).

PROPOSED NEW RULES
Several amendments to the regulations discussed above have recently been proposed. They could affect the requirements applicable to shippers and transporters of radioactive material. First, the NRC has proposed major revisions to 10 CFR Part 71 to make it compatible with IAEA Safety Standard TS-R-1 (formerly ST-1) which was adopted in 1996. 65 Fed. Reg. 44,360 (2000). In July 2001, DOT "harmonized" its regulations with international standards such as TS-R-1. Second, DOT has proposed a clarification of the applicability of its hazardous materials regulations to loading, unloading, and storage operations. 66 Fed. Reg. 32,420 (2001). Third, DOT has proposed revising the level

of knowledge required for civil penalty enforcement proceedings. 66 Fed. Reg. 42,909 (2001). Fourth, DOT has issued an advanced notice of proposed rulemaking for 49 CFR regarding hazardous waste manifest requirements. 66 Fed. Reg. 41,490 (2001).

CONCLUSION

The regulations pertaining to the transportation of radioactive materials are voluminous. This paper does not attempt to provide a substitute for them. Nevertheless, this overview, used in conjunction with DOT's Radioactive Material Regulations Review and other useful agency publications, should assist shippers and carriers in navigating and complying with the applicable rules.

APPENDIX: USEFUL PUBLICATIONS

A wide variety of helpful information is readily available from DOT, NRC, and the Postal Service. Much of this material may be downloaded directly from agency websites.

DOT

- DOT's "Radioactive Material Regulations Review," available at http://hazmat.dot.gov/pubtrain/ramreview.pdf, is a 77-page comprehensive guidebook to be used in conjunction with DOT and NRC shipping and transporting regulations in the CFR.
- DOT provides downloadable training modules addressing: Shipping, Marking and Labeling, Placarding, and Carrier Requirements for Highway, Rail, and Air transportation, which are available at: http://hazmat.dot.gov/pubtrain/mod.htm.
- "How to use the Hazardous Materials Regulations," available at http://hazmat.dot.gov/pubtrain/howtohmr.pdf, is a short training guide containing guidance on navigating the DOT regulations.
- Other useful links, including letters of interpretation referenced by regulation, are available at http://hazmat.dot.gov/question.htm. DOT's website provides a comprehensive list of all free DOT publications and all DOT publications available for sale to the regulated community.
- DOT also maintains a Hazmat Information Center (1-800-467-4922) available Monday through Friday from 9:00 a.m. until 5:00 p.m.

NRC

The NRC maintains a "reference library" on its website at http://www.nrc.gov/NRC/reference.html. The library contains many useful links, including links to administrative letters, regulatory guides, a glossary of nuclear terms, and NRC's Inspection Manual. The NRC Office of Public Affairs can be reached at 301-415-8200. The NRC Public Document Room can be reached at 301-415-4737.

Postal Service

The Domestic Mail Manual is available at http://pe.usps.gov. Section C023 of the manual provides guidance on mailing radioactive materials. International shippers should be familiar with the International Mail Manual, also available online. Publication 52, "Hazardous, Restricted, and Perishable Mail," available at http://new.usps.com/cpim/ftp/pubs/pub52.pdf, is a detailed navigation tool for use in conjunction with U.S. Postal Service hazardous material regulations. Packaging Instruction 7A, pp. 305-308 specifically focuses on packaging requirements for radioactive materials.