

Appendix G

Radiological Hazards

- G1. Baseline Conditions for the Management, Storage, Transportation, and Disposal of Spent Nuclear Fuel and High-Level Waste at Diablo Canyon Power Plant
- G2. Radioactive Materials Transportation Experience and Risk Assessments
- G3. US Nuclear Regulatory Commission Environmental Impact Evaluation
- G4. Radiation Basics
- G5. DOT 2008 Radiological Review

§ 178.356 (Specification 20PF) and § 178.358 (Specification 21PF). Handling procedures and packaging criteria for the overpacks must be in accordance with the United States Enrichment Corporation (USEC) Report USEC-651, *Good Handling Practices for Uranium Hexafluoride*.

VI. TRANSPORT CONTROLS

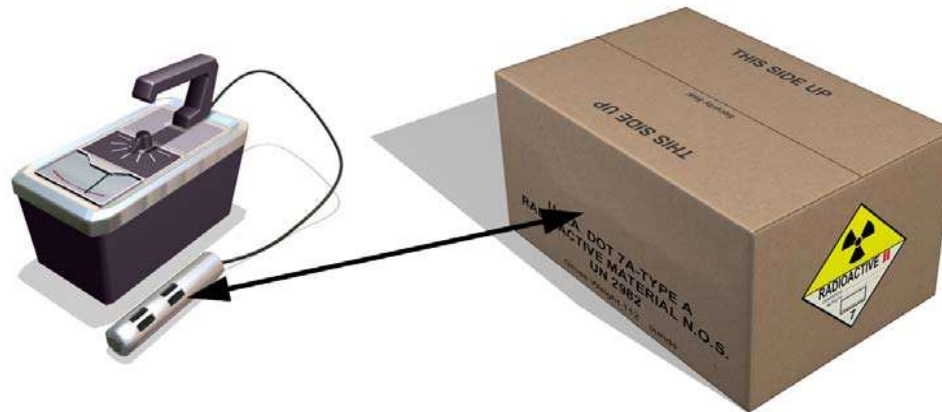
While proper packaging is the primary means of providing safety, transport controls provide additional levels of safety in the transport of radioactive materials. These controls include use of a transport index (TI), a criticality safety index (CSI) for fissile materials, dose rate limits, contamination limits, exclusive use provisions, and use of closed transport vehicles.

Exclusive use means sole use by a single consignor of a conveyance for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee. The consignor and the carrier must ensure that any loading or unloading is performed by personnel having radiological training and resources appropriate for safe handling of the consignment. The consignor must provide to the initial carrier specific written instructions for maintenance of exclusive use shipment controls, including the vehicle survey requirement of § 173.443 (c) as applicable, and include these instructions with the shipping paper information provided to the carrier by the consignor.

A. Transport Index (TI)

The dose rates associated with radioactive material shipments are controlled, in part, by the transport index, often called the TI. The TI is a dimensionless number that restricts the number of radioactive material packages that can be safely accumulated on a conveyance or in a storage area. By definition, 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)). The TI is rounded up to the nearest tenth (except a TI between 0.0 and 0.05 may be taken as zero) and is shown, without units, as the TI on shipping papers and radioactive material labels. Figure 13 illustrates the measurement of a package TI.

Figure 13 - Transport Index



For non-exclusive use shipments, the TI from a single package can not exceed 10.

Conveyance limits on the sum of package transport indices are given in § 173.441(d) and are as follows:

1. Except for shipments by cargo aircraft only or by seagoing vessel, the sum of TIs for a non-exclusive use shipment may not exceed 50.
2. Where a consignment is transported under exclusive use, there is no limit on the sum of the TIs aboard a single conveyance.
3. Provisions for shipments of radioactive materials by air are described in §§ 175.700 - 175.705 and include:
 - a. On a passenger-carrying aircraft—
 - i. Each single package on the aircraft has a TI no greater than 3.0;
 - ii. The combined TI of all the packages on the aircraft must be no greater than 50.
 - b. On a cargo aircraft—
 - i. Each single package on the aircraft has a TI no greater than 10.0.
 - ii. The combined TI of all the packages on the aircraft is no greater than 200.
4. Provisions for shipment of radioactive materials by vessel are described in §§ 176.700 - 176.720 and include the requirement that the sum of the TIs for all packages on board a vessel may not exceed the limits specified in Table 4 (this table does not apply to consignments of LSA-I material).

Packages must be stowed at prescribed distances from areas occupied by persons, based on tables of cumulative TI versus separation distance found in DOT carrier regulations as follows:

- Rail § 174.700
- Air §§ 175.701 – 175.702
- Water § 176.708
- Highway § 177.842

There is a limit of a total TI of 50 for each group of packages in a single spot in storage incident to transportation (with each group of packages at least 6 m (20 ft) from other groups of radioactive packages).

The TI limits for freight containers and conveyances on vessels are listed in Table 4.

Table 4 - TI Limits for Freight Containers and Conveyances on Vessels

Type of freight container or conveyance	Limit on total sum of transport indices in a single freight container or aboard a conveyance	
	Not under exclusive use	Under exclusive use
I. Freight container - small	50	N/A
II. Freight container - large	50	No limit
III. Vessel: ^{a,b}		
1. Hold, compartment or defined deck area:		
i. Packages, overpacks, small freight containers.	50	No limit
ii. Large freight containers.	200	No limit
2. Total vessel:		
i. Packages, overpacks, small freight containers.	200	No limit
ii. 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 § 173.441(b) (exclusive use) may be transported by vessels provided that they are not removed from the vehicle at any time while on board the vessel.

B. Criticality Safety Index (CSI)

In addition to a transport index, packages containing fissile material (those not excepted under § 173.453) must be assigned a criticality safety index (CSI). Like the TI, the CSI is a dimensionless number, rounded up to the next tenth, which is used to provide control over the accumulation of packages, overpacks or freight containers. The CSI for packages containing fissile material is determined in accordance with the instructions provided in 10 CFR §§ 71.22, 71.23, and 71.59; it is determined from the grams of fissile material (plutonium-239, plutonium-241, uranium-233, uranium-235) present in the package. The CSI for an overpack, freight container, or consignment 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, or consignment.

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. For non-exclusive use shipments of fissile material packages, except on vessels, the total sum of CSIs in a freight container or on a conveyance may not exceed 50, for exclusive use shipments the total sum of CSIs may not exceed 100. In temporary storage during transportation, the total CSI in any storage location must not exceed 50. Groups of such packages must be spaced at least 6 m (20 ft) apart.

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 radiation level restrictions of § 173.441 and the specific requirements for the transportation of fissile material packages in § 173.457 are satisfied.

Provisions for shipment of radioactive materials by vessel are described in §§ 176.700 – 176.720 and include the requirement that the sum of the CSIs for all packages radioactive materials on board a vessel may not exceed the limits specified in Table 5 (this table does not apply to consignments of LSA-I material).

Table 5 - CSI Limits for Freight Containers and Conveyances on Vessels

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	N/A
II. Freight container - large	50	100
III. Vessel: ^{a,b}		
1. Hold, compartment or defined deck area:		
i. Packages, overpacks, small freight containers.	50	100
ii. Large freight containers.	50	100
2. Total vessel:		
i. Packages, overpacks, small freight containers.	200	200
ii. Large freight containers.	No limit ^c	No limit ^d

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 § 173.441(b) (exclusive use) 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).

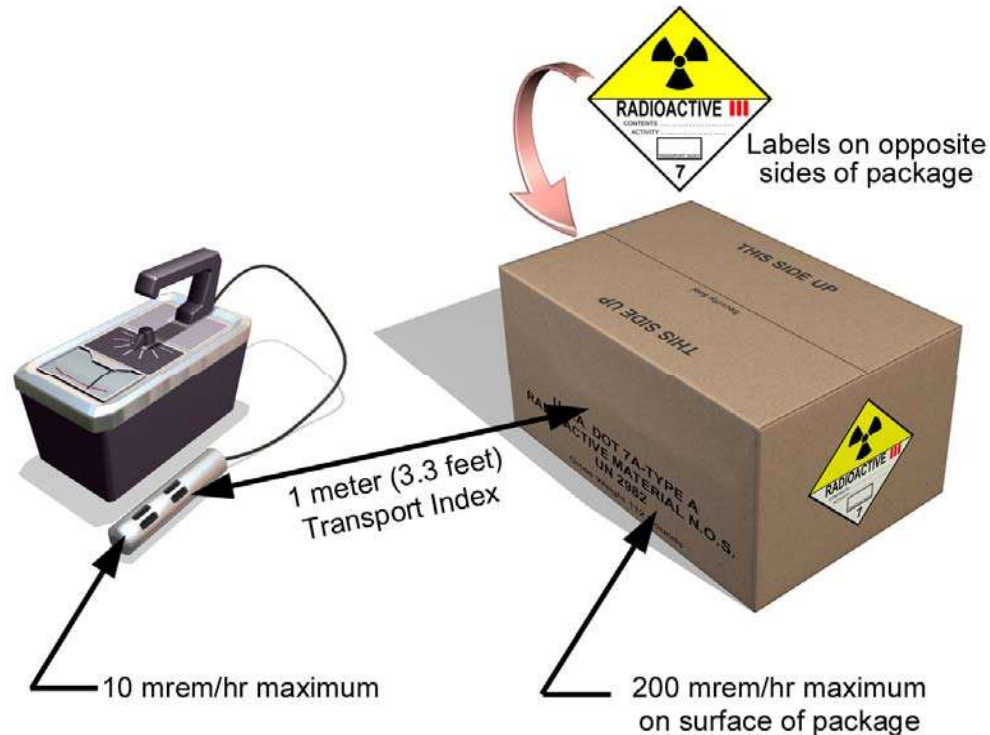
^d The consignment must be handled and stowed such that the total sum of CSIs in any group does not exceed 100, and such that each group is handled and stowed so that the groups are separated from each other by at least 6 m (20 ft). The intervening space between groups may be occupied by other cargo.

C. Package Radiation Limits

The limits on radiation levels of a package offered for transportation are found in § 173.441. (The dose limits for excepted packages are located in §§ 173.421, 424, 426, and 428; at 0.005 mSv/h (0.5 mrem/h) these limits are significantly lower than what is allowed for other radioactive material packages.)

For non-excepted packaging, packages are restricted to surface readings not exceeding 2 mSv/h (200 mrem/h) and a transport index (TI) that does not exceed 10 as shown in Figure 14. These limits apply for non-exclusive use shipments and help to ensure that transport personnel do not receive significant doses, even when frequently handling a large number of packages.

Figure 14- Package Radiation Limits for Non-Exclusive Use Shipments



Packages may be shipped with higher dose rates if they are placed under additional controls. For packages with surface readings under 2 mSv/h (200 mrem/h), but with a TI exceeding 10, the shipment may be placed under exclusive use. Packages having a surface reading over 2 mSv/h (200 mrem/h), up to as high as 10 mSv/h (1,000 mrem/h), must not only be placed under exclusive use but also must be shipped in a closed transport vehicle with the package secured in place with no loading or unloading operations between the beginning and end of the transportation. (A “closed transport vehicle” includes not only closed trailers and vans, but also arrangements where personnel barriers to limit access are placed around large packages carried on flat bed trailers.)

For exclusive use shipments, the vehicle radiation levels must not exceed the following during transportation:

- 2 mSv/h (200 mrem/h) at any point on the outer surfaces of the vehicle;
- 0.1 mSv/h (10 mrem/h) at any point 2 m (6.6 feet) from the outer lateral surfaces of the vehicle (excluding the top and underside of the vehicle);
- 0.02 mSv/h (2 mrem/h) in any normally occupied space, (this does not apply to carriers if they operate under the provisions of a State or federally-regulated radiation protection program and if personnel under their control who are in such an occupied space wear radiation dosimetry devices).

Figures 15 and 16 illustrate the allowable dose rates for exclusive use shipments.

Figure 15 - Allowable Dose Rates for an Exclusive Use Shipment

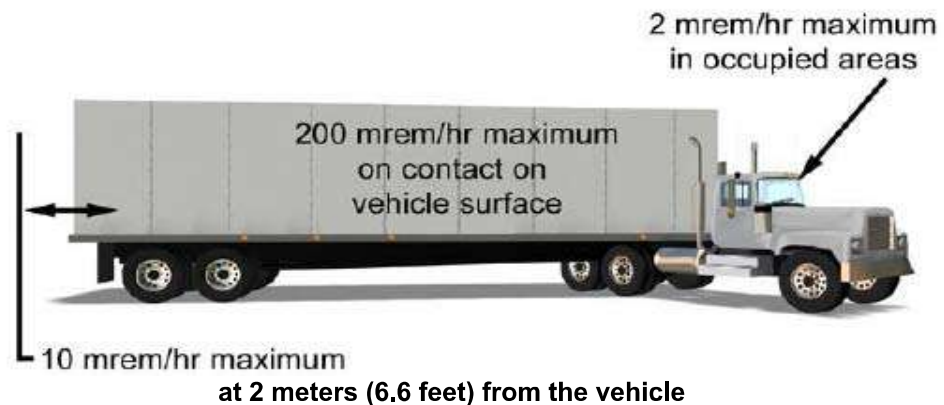


Figure 16- Allowable Dose Rates for an Exclusive Use Shipment in a Closed Transport Vehicle

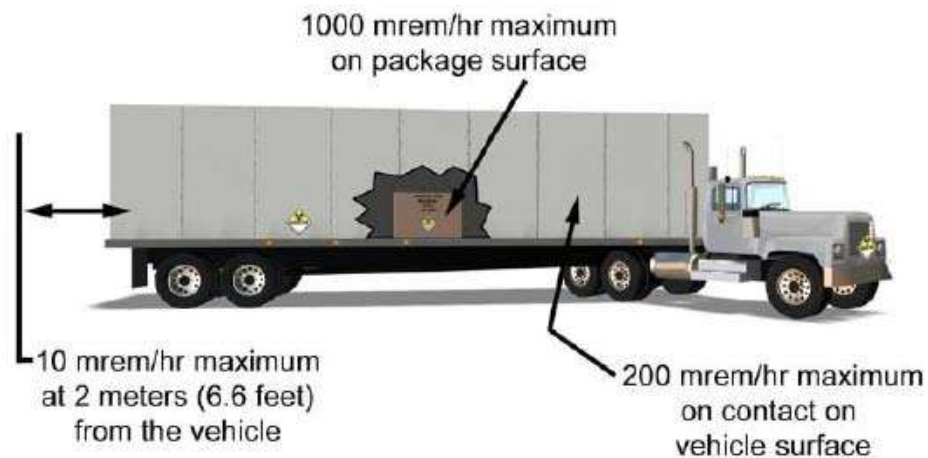


Table 6 summarizes the radiation level limits packages and transport vehicles in various configurations.

Table 6 - Radiation Level Limitations

Package and Vehicle Radiation Level Limits (§ 173.441) ¹				
		Nonexclusive Use Shipment	Exclusive Use Shipment	
		Open or Closed Transport Vehicle	Open (flat-bed)	Closed Transport Vehicle
Package Limits:	External Surface	2 mSv/h (200 mrem/h)	2 mSv/h (200 mrem/h)	10 mSv/h (1000 mrem/h)
	Transport Index (TI) ²	10	No limit	
	Criticality Safety Index (CSI) ⁵	50	No limit	
Transport Vehicle Limits (highway and rail):	Any point on the outer surface	N/A	N/A	2 mSv/h (200 mrem/h)
	Vertical planes projected from outer edges		2 mSv/h (200 mrem/h)	N/A
	Top of		Load: 2 mSv/h (200 mrem/h)	Vehicle: 2 mSv/h (200 mrem/h)
	2 meters from		Vertical Planes: 0.1 mSv/h (10 mrem/h)	Outer Lateral Surfaces: 0.1 mSv/h (10 mrem/h)
	Underside		2 mSv/h (200 mrem/h)	
	Occupied position	N/A ³	0.02 mSv/h (2 mrem/h) ⁴	
	Sum of package TIs	50	No limit	
	Sum of package CSIs ^{5,6}	50	100	

¹ The limits in this table do not apply to excepted packages. [§§ 173.421, 173.424, 173.426, and 173.428]
² The dimensionless number equivalent to maximum radiation level at 1 meter (3.3 feet) from the exterior package surface is in mrem/h rounded up to the next tenth. [§ 173.403]
³ No dose limit is specified, but separation distances apply to packages with RADIOACTIVE YELLOW-II, RADIOACTIVE YELLOW-III, or CSI labels. (§ 177.842)
⁴ Does not apply to carriers if operating under a state or federally-regulated radiation protection program and if personnel wear radiation dosimetry devices. [§ 173.441(b)(4)]
⁵ These provisions do not apply to shipment by vessel. See § 176.700–720 for the vessel requirements.
⁶ The number of packages containing fissile material stored in transit in any one storage area must be limited so that the total sum of the CSIs is ≤50 and such groups of packages must be spaced at least 6 meters (20 feet) from other such groups. [§§ 173.457 and 173.459]

D. Contamination Limits and Contamination Surveys

Removable, or non-fixed, contamination on the surface of radioactive material packages must be kept as low as reasonably achievable. The maximum removable surface contamination limits are stated in § 173.443 and are shown in Table 7.

Table 7 - Non-Fixed External Radioactive Contamination Limits for Packages

Contaminant	Maximum permissible limits		
	Bq/cm ²	μCi/cm ²	dpm/cm ²
Beta and gamma emitters and low toxicity alpha emitters	4	10 ⁻⁴	220
All other alpha emitting radionuclides	0.4	10 ⁻⁵	22

These levels are the surface limits for removable contamination. Usually, smears are used to assess the removable contamination levels. It is assumed that the smear technique has 10% efficiency. Therefore, shippers should multiply the smear data by 10 before comparing it to the limits. Taking account of this factor, the limits based on wipe data are as shown in Table 8.

Table 8 - Non-Fixed External Radioactive Contamination *Wipe* Limits for Packages

Contaminant	Maximum permissible <i>wipe</i> limits		
	Bq/cm ²	μCi/cm ²	dpm/cm ²
Beta and gamma emitters and low toxicity alpha emitters	0.4	10 ⁻⁵	22
All other alpha emitting radionuclides	0.04	10 ⁻⁶	2.2

* Assuming 10% smear efficiency

In addition, since smears are to be done over 300 cm², shippers should be careful to ensure that they convert to /cm² before making comparisons between the smear data and the values in the table. Techniques other than smears may be used to assess the removable contamination if they have equal or greater efficiency.

The contamination limits cited above apply to all non-exclusive use shipments of radioactive material packages. For packages shipped as exclusive use shipments by rail or highway, the contamination levels must not exceed the Table 7 limits at the beginning of transport, but may increase up to 10 times the limits during transport. This provision allows for the phenomenon of weeping (or leaching) whereby under certain conditions, packages will have fixed contamination that will migrate, or weep, to the outer surface and become removable.

If non-fixed surface contamination levels on packages in an exclusive use vehicle have risen during transportation above the Table 7 limits, the transport vehicle must be surveyed with appropriate radiation detection instruments after each use. It shall not be returned to service until the external radiation on the surface is below 0.005 mSv per hour (0.5 mrem per hour) and the removable surface contamination is below the limits of Table 7 (see §§ 177.843 and 174.715). These requirements do not apply to any vehicle used solely for transporting Class 7 (radioactive) material if a survey of the interior surface shows that the radiation dose rate does not exceed 0.1 mSv per hour (10 mrem per hour) at the interior surface or 0.02 mSv per hour (2 mrem per hour) at 1 meter (3.3 feet) from any interior surface. These vehicles must be stenciled with the words “For Radioactive Materials Use Only” in lettering at least 7.6 cm (3 inches) high in a conspicuous place, on both sides of the exterior of the vehicle. These vehicles must be kept closed at all times other than loading and unloading. The vehicles do not have to be decontaminated to the Table 7 limits until they are released back to general service.

VII. SHIPMENTS OF LOW SPECIFIC ACTIVITY (LSA) MATERIALS AND SURFACE CONTAMINATED OBJECTS (SCO)

As described in Section IV, low specific activity (LSA) material is radioactive material that has a low activity per unit mass (specific activity) and surface contaminated objects (SCO) are solid objects which are not themselves radioactive but which have radioactive material distributed on their surfaces. LSA implies *activity within* a material, while SCO implies *activity on* a material.

Low Specific Activity (LSA) material and Surface Contaminated Objects (SCO) are extremely important radioactive material classifications with respect to shipments of low-to-medium level radioactive waste materials. The majority of shipments of such wastes originating from the nuclear fuel cycle facilities, and from all kinds of industrial, medical, research and academic communities are in the form of varying types of LSA materials. The SCO category addresses solid wastes generated in the form of non-radioactive contaminated materials originating from cleanup, remediation and decontamination activities.

A. Transport Requirements for LSA Materials and SCO

Transport requirements specific to LSA materials and SCO may be found in § 173.427.

The quantity of LSA material or SCO in a single package must be restricted so that the external radiation level from the unshielded material does not exceed 10 mSv/h (1 rem/h) at 3 meters from the unshielded material. Compliance with this requirement does not allow taking credit for shielding provided by the packaging; the inherent property of the material must be limited so that even without any shielding, the dose rate would not exceed the limit. If the external radiation level from the unshielded material exceeds 10 mSv/h at 3 meters, the material may not be considered LSA or SCO, and it will require Type B packaging.

There are restrictions on the total activity of all SCO and some LSA transported in a conveyance. An activity restriction of 100 A₂ per conveyance applies to all SCOs and to LSA-II and LSA-III materials that are combustible solids or are in liquid or gaseous form.

LSA materials and SCO must be either non-fissile or fissile-excepted under § 173.453.

Packages of SCO and LSA materials must meet the contamination control limits in § 173.443 and the dose limits in § 173.441 discussed in Section VI.C and VI.D above.

Domestic shipments containing less than an A₂ quantity that are conducted as exclusive use are excepted from the marking and labeling requirements in 49 CFR Part 172. However, packages and unpackaged materials must be marked with “RADIOACTIVE—LSA” or “RADIOACTIVE—SCO”, as appropriate and with “RQ” if the materials contain a hazardous substance. Unless the material is unconcentrated uranium or thorium ores, placards are required for exclusive use shipments of LSA and SCO shipped in excepted packaging under § 173.427(b)(4); liquid LSA-I material; or unpackaged LSA material or SCO.

B. Packages for LSA Materials and SCO

LSA materials and SCO may be shipped in a variety of package types, depending on their characteristics and the method of shipment.

1. Unpackaged LSA Material and SCO

LSA material and SCO in groups LSA-I and SCO-I may be transported “unpackaged”, that is, the material may be shipped without packaging within a freight container, tank, intermediate bulk container or closed conveyance, under the following conditions (see § 173.427(c)):

- The material must be transported in a manner that ensures no release of contents from the conveyance and no loss of shielding under normal conditions of transport.
- Except for SCO-I material with specified low contamination levels, the shipment must be exclusive use. The conveyance must be surveyed and decontaminated, if necessary, in accordance with § 173.443(c), prior to unrestricted release of the conveyance.
- For SCO-I material with removable contamination above specified limits, measures must be taken to ensure that the radioactive material is not released inside the conveyance or to the environment.

2. Excepted Packages of LSA Material and SCO

For domestic transportation only, excepted packaging is authorized when the LSA material or SCO is transported in an exclusive use vehicle and does not exceed an A₂ quantity in each package. The packaging must meet the “General Design Requirements” of §§ 173.410, 173.24 and 173.24a.

3. Industrial Packages of LSA Material and SCO

Various industrial packages may be used for LSA materials or SCO based on the potential radiological hazard of the material to be transported. LSA-I materials can be shipped in IP-1 packagings, LSA-II and LSA-III materials require more durable IP-2 and IP-3 packagings. LSA material in liquid form requires more durable IP packaging than solid LSA material. Similarly, non-exclusive use shipments do not have the controls during transport that may exist for exclusive use shipments; thus non-exclusive use LSA requires packagings of a greater integrity than are required for exclusive use shipments. The categories of IP packages required for different LSA and SCO materials shipped under different transportation conditions are illustrated in Table 9.

Table 9 - Industrial Package Integrity Requirements for LSA Material and SCO

Contents	Industrial Packaging Type	
	Exclusive Use Shipment	Non-Exclusive Use Shipment
1. LSA-I:		
Solid	IP-1	IP-1
Liquid	IP-1	IP-2
2. LSA-II:		
Solid	IP-2	IP-2
Liquid	IP-2	IP-3
3. LSA-III	IP-2	IP-3
4. SCO-I	IP-1	IP-1
5. SCO-II	IP-2	IP-2

4. Type A Packages for LSA Material and SCO

For domestic transportation only, DOT-7A Type A packaging may be used.

5. Type B Packages for LSA and SCO

Type B packages are usually used for materials other than LSA and SCO. However, they may be used if the radioactivity and physical form of the LSA or SCO to be shipped are such that it can be considered one of the authorized contents for a particular Type B package.

6. Packages for Exclusive Use Transport of Liquid LSA-I

Exclusive use transport of liquid LSA-I must be done, in either:

- Specification 103CW, 111A60W7 tank cars. Bottom openings in tanks are prohibited; or
- Specification MC 310, MC 311, MC 312, MC 331 or DOT 412 cargo tank motor vehicles. Bottom outlets are not authorized. Trailer-on-flat-car service is not authorized.

7. Typical Packages for Radioactive Waste Shipped as LSA or SCO

Figure 17 shows typical packaging and shipping configurations for materials classified as LSA materials or SCO.

Figure 17 - Typical Packages for LSA Materials and SCO



Figure A - Intermodal Container

Depending on the contents or other packaging, it may be a conveyance, bulk packaging, excepted, or IP packaging.



Figure B - Steel Drum Depending on content and inner packaging, it may be a Type A, IP-1, -2, or -3.



Figure C - Shielded LSA Cask
Type A, IP-2 and IP-3.



Figure D - Metal Box
Type A or IP

VIII. HAZMAT COMMUNICATIONS AND RELATED REQUIREMENTS

Shippers have the greatest responsibility for compliance with the communication requirements of Part 172 of 49 CFR, but carriers are also subject to some of the requirements. Safe transportation of radioactive material requires correct communication of the specific hazards of the materials. Generally, an essential part of the total system for providing safety in transport of radioactive material is the requirement for communication of information on the specific hazards of the materials. The communication requirements of 49 CFR Part 172 are designed to complement the basic safety requirements for package activity limitation and package integrity. Historically, Part 172 has addressed the conventional communication requirements, such as, proper shipping papers, package marking, package labeling, and vehicle placarding. In recent years, additional subparts have been added to Part 172 to address emergency response information, hazmat employee training, and security plans.

A. Hazardous Materials Table

Subpart A of Part 172 describes the applicability of the regulations to shippers and carriers. Subpart B contains the hazardous materials table. The Hazardous Materials Table (HMT) in § 172.101 classifies those materials which DOT has designated as hazardous materials for purposes of transportation. The HMT prescribes the requirements for shipping papers, marking, and labeling applicable to the shipment and transportation of those hazardous materials. For each listed material, the table identifies the hazard class, the UN identification number, and gives the proper shipping name or directs the user to the proper shipping name. In addition, the HMT specifies or references other regulatory requirements pertaining to labeling, packaging, and quantity limits aboard aircraft and stowage of hazardous materials aboard vessels.

Before using the HMT, shippers should be familiar with the ground rules which explain the information in the ten columns of the table, and the explanatory symbols (see §§ 172.101(a)-(l) that precede the HMT). The information in the paragraphs preceding the HMT provides extensive information related to the proper use of the table and the information in the table.

B. Proper Shipping Names for Radioactive Materials

The list of proper shipping names for radioactive material, along with their UN identification numbers as shown in the HMT, is given in Table 10.

Table 10 - Radioactive Material Proper Shipping Names and Identification Numbers

Hazardous materials description and proper shipping names	Identification Numbers
Radioactive material, excepted package-articles manufactured from natural uranium <i>or</i> depleted uranium <i>or</i> natural thorium.	UN2909
Radioactive material, excepted package-empty packaging.	UN2908
Radioactive material, excepted package-instruments <i>or</i> articles.	UN2911
Radioactive material, excepted package-limited quantity of material.	UN2910
Radioactive material, low specific activity (LSA-I) <i>non fissile or fissile-excepted.</i>	UN2912
Radioactive material, low specific activity (LSA-II) <i>non fissile or fissile-excepted.</i>	UN3321
Radioactive material, low specific activity (LSA-III) <i>non fissile or fissile excepted.</i>	UN3322
Radioactive material, surface contaminated objects (SCO-I <i>or</i> SCO-II) <i>non fissile or fissile-excepted.</i>	UN2913
Radioactive material, transported under special arrangement <i>non fissile or fissile excepted.</i>	UN2919
Radioactive material, transported under special arrangement, fissile.	UN3331
Radioactive material, Type A package, fissile <i>non-special form.</i>	UN3327
Radioactive material, Type A package <i>non-special form non fissile or fissile-excepted.</i>	UN2915
Radioactive material, Type A package, special form <i>non fissile or fissile-excepted.</i>	UN3332
Radioactive material, Type A package, special form, fissile.	UN3333
Radioactive material, Type B(M) package, fissile.	UN3329
Radioactive material, Type B(M) package <i>non fissile or fissile- excepted.</i>	UN2917
Radioactive material, Type B(U) package, fissile.	UN3328
Radioactive material, Type B(U) package <i>non fissile or fissile-excepted.</i>	UN2916
Radioactive material, uranium hexafluoride <i>non fissile or fissile-excepted.</i>	UN2978
Radioactive material, uranium hexafluoride, fissile.	UN2977

These proper shipping names have been harmonized with those used internationally; there are no longer any generic proper shipping names for radioactive material with the phrase “not otherwise specified (n.o.s).” Most of the proper shipping names are based on the type of package used for the shipment. If the packaging type matches the contents, this is straightforward. However, if the shipper uses a higher-rated package than required for the contents, then either the package markings may be left as is and the proper shipping name consistent with that *packaging* is used, or the proper shipping name based on the *contents* is used, in which case the packaging markings are altered to be consistent.

C. Shipping Paper Requirements

As with other hazardous materials shipments, certain essential elements of information must be included on shipping papers. The availability of a complete and correct shipping paper description for a hazardous material shipment is vital not only to the carrier and the consignee, but also to emergency response personnel in the event of an incident.

1. Basic Shipping Paper Requirements

The shipping paper description must basically include the following:

- The basic shipping description, which consists of;
 - The UN Identification number from Column (4) of the § 172.101 table;
 - The proper shipping name from Column (2) of the § 172.101 table;
 - The UN hazard class or division - radioactive material is hazard class 7;
- The net quantity of material by mass, volume, or for Class 7 materials, activity. *NOTE: For most radioactive material, it is not required to list the weight or volume, since the additional requirements of § 172.203(d) provide better information, i.e., the radioactivity content in becquerels (curies). A listing of weight or volume is usually needed only with respect to establishing freight charges;*
- The letters “RQ”, if the shipment is a “hazardous substance”, either before or after, the basic description [see § 172.101, Appendix A, Table 2 for RQ values of radionuclides].
- Emergency response telephone number as prescribed in Subpart G, Part 172.

A shipping paper may contain additional information concerning the material, provided it is not inconsistent with, and does not cause confusion with, the basic description. Unless otherwise specified, the additional information must be placed after the required basic description.

2. Additional Shipping Paper Description for Radioactive Material

Section 172.203(d) details the additional shipping paper description for radioactive material, and this information, as appropriate, follows the basic description:

- The name of each radionuclide in the material as listed in § 173.435. Abbreviations, e.g., “⁹⁹Mo,” are authorized;
- For mixtures of radionuclides, only the radionuclides that constitute 95% of the hazard of the mixture as described in § 173.433(g) need be listed on shipping papers and package labels (see Section VIII.C.4 of this document).
- A description of the physical and chemical form of the material, if the material is not in special form (generic chemical description is acceptable for chemical form).
- The activity contained in each package of the shipment in terms of the appropriate SI units (e.g., Becquerels (Bq), Terabecquerels (TBq), etc.). The activity may also be stated in appropriate customary units (curies (Ci), millicuries (mCi), microcuries (uCi), etc.) in parentheses following the SI units. Abbreviations are authorized. (The weight in grams or kilograms of fissile radionuclides may be inserted *instead* of activity units, except for plutonium-239 and plutonium-241. For plutonium-239 and plutonium-241, the weight in grams of fissile radionuclides may be inserted in *addition* to the activity units.)
- The category of label applied to each package in the shipment. For example: “RADIOACTIVE WHITE-I.”
- The transport index assigned to each package in the shipment bearing RADIOACTIVE YELLOW-II or RADIOACTIVE YELLOW-III labels.
- For a package containing fissile material:
 - The words “Fissile Excepted” if the package is excepted pursuant to § 173.453; or otherwise
 - The criticality safety index for that package.
- For a package approved by the U.S. Department of Energy (DOE) or U.S. Nuclear Regulatory Commission (NRC), a notation of the package identification marking as prescribed in the applicable DOE or NRC approval (see § 173.471).
- For an export shipment or a shipment in a foreign-made package, a notation of the package identification marking as prescribed in the applicable International Atomic Energy Agency (IAEA) Certificate of Competent Authority which has been issued for the package (see § 173.473).

- For a shipment required to be consigned as exclusive use:
 - An indication that the shipment is consigned as exclusive use; or
 - If all the descriptions on the shipping paper are consigned as exclusive use, then the statement “Exclusive Use Shipment” may be entered only once on the shipping paper in a clearly visible location.
- For the shipment of a package containing a highway route controlled quantity of Class 7 (radioactive) materials the words “Highway route controlled quantity” or “HRCQ” must be entered in association with the basic description.

3. Other Information and Examples of Shipping Papers Entries

As indicated above, a great deal of specific information is required on shipping papers for radioactive material. While there is no precise prescription for the shipping paper format, the first three entries of the basic description must be in a specific order. In a final rule published under Docket HM-215I on December 29, 2006, DOT established new requirements for shipping descriptions on shipping papers. Previously, the basic description of a hazardous material consisted of the proper shipping name, hazard class, ID number and packing group (packing group is not applicable to Class 7), in that order. The HMR had also authorized an alternative description sequence, which lists the identification number first, followed by the proper shipping name, hazard class, and packing group (not applicable to Class 7). Beginning January 1, 2007, the alternative shipping description sequence became mandatory on shipping documents prepared in accordance with the ICAO Technical Instructions and the IMDG Code. The older sequence can be used until January 1, 2013 on other shipments; thereafter all shipping descriptions of a hazardous material must be indicated on a shipping paper in the following manner (as described earlier):

- Identification (ID) number listed first, followed by
- the proper shipping name,
- hazard class, and
- packing group (not applicable to Class 7).

Other descriptive information is allowed, such as the functional description of the product or the applicable regulatory citation under which the shipment is offered. This additional description must not confuse or detract from the required description. The following are some example entries of different ways shipments can be described on shipping papers:

Example 1:

One (1) box UN 2916, Radioactive material Type B(U) package, 7, RQ, 22.7 kg Gross, Iridium - 192, Special Form, 2.2 TBq Radioactive Yellow-II, Transport Index 0.6 USA/9033/B(U), In emergency, contact: 1-800-000-0000.

Example 2:

One (1) box UN 2915, Radioactive material Type A package, Class 7(8), 7.8 kg gross, ⁶⁰Cobalt, 0.01 GBq, liquid, cobalt in 50 ml 5% hydrochloric acid solution, Radioactive Yellow-III and Corrosive labels applied, TI= 1.8, Emergency contact: 1-800-000-0000.

Example 3:

One (1) box UN2915, Radioactive material Type A package, 7(5.1), 10 kg net, Thorium natural, as powdered solid thorium nitrate 48 MBq (1.3 mCi), Radioactive Yellow-II and 5.1 labels, TI 0.1 DOT Spec. 7A, Cargo aircraft only, In emergency contact: 1-800-000-0000.

NOTE: Although this material is LSA-I, as an oxidizer, it must be packaged and shown on the shipping papers in accordance with the specific packaging requirements of Section 173.419, with air shipment limited to not more than 11.3 kg.

Example 4:

Three (3) drums UN 3321, Radioactive material low specific activity (LSA-II), 7, 363kg ea., ¹³⁷Cs, ⁶⁰Co and ⁹⁰Sr, Solid, elemental and inorganic salts in non-compacted solid debris and waste

Drum No.	Activity (MBq)
731	1.5
680	0.57
541	0.18

See attached Radwaste Manifest XZ 00052, Exclusive-use shipment. In emergency, contact (24-hour) 1-800-000-0000.

NOTE: This is an example of a shipment under § 173.427(b)(4).

Example 5:

(3) boxes

UN 2915, Radioactive material Type A package, 7,
Box No.1, catalytic specimen, ^{35}S , 2.6 GBq
solid, powdered metal oxide matrix,
Radioactive White-I label, 60 lb

Box No.2, Tagged solvent, ^{30}Cl , 0.11 GBq
liquid, nonflammable organic
Radioactive White-I label, 50 lb

Box No. 3, converter element, ^{59}Fe and ^{55}Fe
1.1 GBq and 0.74 GBq, solid, steel part
Radioactive Yellow-III label, TI 1.6, 80 lb

NOTE: This is an example of how one basic entry can be used along with three different packages. Detailed information is given on the content, labels, and TI of each package.

Example 6:

4 cyl.

UN 2977, Radioactive material uranium hexafluoride fissile, 7(8),
Total Gross Wt. 18,795 kg
Solid Uranium Hexafluoride (UF_6) contained in four Model 30B steel cylinders, each enclosed in a Model UX-30 protective overpack, Each cylinder contains 2,277 kg of UF_6 , 63 kg ^{235}U (629 MBq) 5.0 % ^{235}U enrichment
NRC Certificate USA/9196/AF, Type A
Radioactive Yellow-III labels, TI=5.0/package, CSI=5.0/package.
Radioactive and Corrosive placards and orange 2977 UN panel applied.
24-hour Emergency Telephone No.: contact 1-888-888-8888.

4. 95% Rule for Mixtures

The “95% Rule” for listing mixtures of radionuclides on shipping papers and labels is given in § 173.435(g), which states, “For mixtures of radionuclides, the radionuclides (n) that must be shown on shipping papers and labels in accordance with §§ 172.203 and 172.403 of this subchapter, respectively, must be determined on the basis of the following formula:

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

Where:

$n+m$ represents all the radionuclides in the mixture
 m are the radionuclides that do not need to be considered
 $a_{(i)}$ is the activity of radionuclide i in the mixture; and
 $A_{(i)}$ is the A_1 or A_2 value as appropriate for radionuclide i .

For example, consider a shipment of radionuclides in normal form where the contents of the package are as follows: 0.3 TBq of Co-60, 0.0002 TBq of Sr-90, 0.018 TBq of Cs-137, 0.016 TBq of I-131, and 0.011 TBq of Sr-89. The summation terms are as follows:

Isotope	Activity [TBq]	A_2 [TBq]	Contribution = $\frac{a_{(i)}}{A_{(i)}}$
Co-60	0.3	0.4	$= \frac{0.3}{0.4} = 0.75$
Sr-90	0.0002	0.3	$= \frac{0.0002}{0.3} = 6.7E-4$
Cs-137	0.018	0.6	$= \frac{0.018}{0.6} = 0.03$
I-131	0.016	0.7	$= \frac{0.016}{0.7} = 0.023$
Sr-89	0.011	0.6	$= \frac{0.011}{0.6} = 0.183$

The summation of each contribution is 0.987 and 95% of this value is 0.937; so it is necessary to list the largest radionuclide quantities until a contribution level of 0.937 is reached. Co-60 and Sr-89 are the 2 largest contributors, and the summation of their contributions is 0.933, so the next largest contributor is needed to reach the 95% value of 0.937, and that radionuclide is Cs-137.

Thus, the radionuclides that will need to be listed as “contents” on the shipping paper and label are: Co-60, Sr-89 and Cs-137. Note that the 95% Rule does not always list the radionuclides with the highest activity values, as the rule is dependent on the relative ratio of activity to A_1/A_2 values for each radionuclide.

5. Documentation for Excepted Packages

As noted in Section V.B, packages shipped according to the exceptions provided in §§ 173.421, 173.424, 173.426 and 173.428 (for limited quantity, instruments or articles, articles manufactured from natural or depleted U or natural Th, and empty radioactive material packaging) are excepted from the detailed shipping paper description requirements. With the addition of the requirement to mark these excepted packages, certification statements are no longer required. (However, a shipping paper is required if the radioactive material in the excepted package meets the definition of a hazardous substance or hazardous waste (as defined in § 171.8)).

Although shipping papers are not required for these excepted packages (with UN identification numbers 2908, 2909, 2910, and 2911), they are not forbidden. In addition, when shipping excepted packages by air, a prescribed statement on an airbill is required by ICAO and IATA regulations.

6. Shipper's Certification

Unless excepted, a shipping paper must include a certification statement, signed by the person offering the package for transport. The certification must appear on the paper that lists the required shipping description.

The following statement listed in § 172.204(a)(1) (or an alternate statement listed in §172.204(a)(2)) must be used for all hazardous materials shipments except for those by air:

“This is to certify that the above-named materials are properly classified, described, packaged, marked, and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.”

For air transportation, the following language may be included on shipping papers in place of the above statement:

“I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and in proper condition for carriage by air according to applicable national governmental regulations.”

The requirements and limitations for carriage of radioactive materials aboard aircraft are prescribed in §§ 175.75(a)(3) and 175.700 through § 175.705. The following statement, with deletion marking, is required for all hazardous material (including radioactive material) shipments by air:

“This shipment is within the limitations for passenger carrying/cargo aircraft only (delete non-applicable).”

D. Marking Requirements

General marking requirements for all hazardous materials are provided in §§ 172.301 and 172.302. Specific requirements for Class 7 materials are located in § 172.310.

1. Basic Marking Requirements

Marking for non-bulk hazardous material packaging includes the following (some exceptions apply):

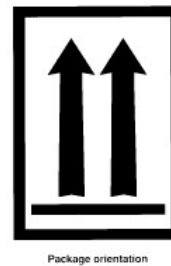
- Proper shipping name
- UN ID number (required on ALL packages, including excepted and empty)
- Name and address of the consignee or consignor
- RQ, if a “hazardous substance”
- DOT-SP Number, if shipped under a DOT Special Permit.

All required markings must be durable, in English, and displayed in a manner so as to not obscure them or reduce their effectiveness. Markings may either be printed on the surface of the package itself or on a label, tag, or sign (see § 172.304).

2. Marking Requirement for Liquids

Each non-bulk combination package with inner packaging containing liquid hazardous materials must be marked with arrows on two opposite sides to indicate the upward position of the inside packaging (see Figure 18). Such marking must be on two opposite sides, with the double arrows in the symbol pointing in the correct upright direction. Arrows for any other purpose may not be displayed on a package containing a liquid hazardous material. There are some exceptions to this rule (see § 172.312(c)). These exceptions include Class 7 radioactive material in Type A, IP-2, IP-3, Type B(U), or Type B(M) packages and non-bulk packages with hermetically sealed inner packagings.

Figure 18 - Package Orientation Marking for Liquid Packages



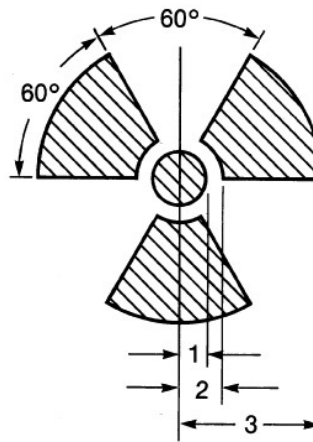
3. Marking Requirements for Radioactive Materials

In addition to the above markings, radioactive materials are subject to the following package marking requirements (see §§ 172.310, 173.471(b), 173.472(c), 173.473(b), and 178.350):

- Gross weight if > 50 kg (110 lb)
- “TYPE IP-1”, “TYPE IP-2”, “TYPE IP-3”, “TYPE A” “TYPE B(U)”, or “TYPE B(M),” as appropriate to the package
- For each IP-1, IP-2, IP-3, or Type A package, the code for the country of origin of design (e.g., “USA”)
- For each DOT 7A Type A packaging:
 - “USA DOT 7A Type A”
 - Name of packaging manufacturer (the person certifying that the package meets all requirements for a Type A package)

- For Type B packages, the trefoil radiation symbol (see Figure 19) - resistant to the effects of fire and water, plainly marked by embossing, stamping or other means resistant to the effects of fire and water (not on a sticky label)
- For Type B and fissile material packages, the applicable DOT, NRC or DOE package certificate ID number, as specified in the relevant certificate, e.g., USA/9166/B(U)-85
- Exclusive use domestic transportation of LSA materials and SCO is excepted from other marking requirements but must be stenciled or marked as “RADIOACTIVE – LSA” or “RADIOACTIVE – SCO,” as appropriate
- Excepted packages are excepted from other marking requirements but must be marked with the UN identification number for the material.

Figure 19- Trefoil Symbol



{1=Radius of Circle (Minimum dimensions 4 mm (0.16 inch) for markings and labels, 12.5 mm (0.5 inch) for placards), 2=1.5* Radius, 3= 5* Radius for markings and labels,= 4.5*Radius for placards.}

4. Marking of Bulk Radioactive Material Packages

Bulk packaging for a hazardous material is defined in § 171.8. The concept of bulk packaging reflected in that definition is that the packaging may involve the vehicle itself, such as a freight container or other large closed receptacle in which the hazardous material is loaded with no intermediate form of containment. Traditionally, the DOT has viewed Type A and Type B radioactive material packaging as non-bulk packaging.

Bulk radioactive material packaging is, therefore, most likely to involve conveyances such as the following:

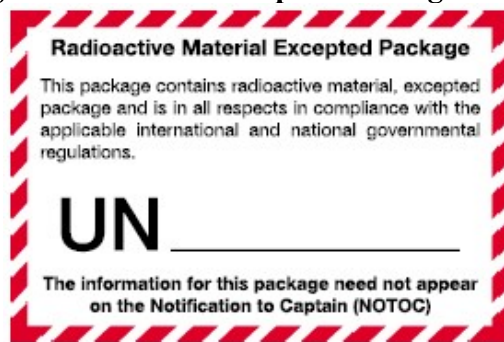
- Tightly closed trucks/vans or railcars containing contaminated soils and debris
- Large bins or freight containers for solids
- Tanks containing slurries or other liquid waste.

For such shipments, the bulk packaging must be marked on its exterior with the applicable UN hazard ID number (see § 172.302). When required for radioactive material, this ID number must be placed on either an orange rectangular panel adjacent to the required radioactive placard (see § 172.332.) or on a plain white square-on-point display configuration having the same outside dimensions as a placard (see § 172.336(b)). According to § 172.334(a), the ID number may not be placed on the radioactive placard in lieu of the word *Radioactive* for domestic shipments; however, this prohibition does not exist in the international (IAEA and IMO) regulations.

E. Labeling Requirements

Each package of Class 7 (radioactive material), unless excepted, must be labeled on two opposite sides, with a distinctive warning label. Excepted packages, and domestic shipments of LSA materials and SCO that are conducted as exclusive use are excepted from the labeling requirements. However, while not a DOT requirement, the ICAO Technical Instructions require excepted packages that are to be shipped by air to have a “Radioactive materials, Excepted Package” label as shown in Figure 19 .

Figure 20 - ICAO Excepted Package Label



Each of the three label categories, i.e., “RADIOACTIVE WHITE-I”, “RADIOACTIVE YELLOW-II”, or “RADIOACTIVE YELLOW-III”, bears the trefoil symbol. Radioactive material labeling is based on the maximum package surface dose rate and the transport index (TI), as shown in Table 11 (taken from § 172.403).

Table 11 - Label Category Based on TI and Surface Radiation Level

Transport Index (TI)	Maximum radiation level at any point on the external surface	Label Category ¹
0 ²	Less than or equal to 0.005 mSv/h (0.5 mrem/h)	WHITE-I
More than 0 but not more than 1	Greater than 0.005 mSv/h (0.5 mrem/h) but less than or equal to 0.5 mSv/h (50 mrem/h)	YELLOW-II
More than 1 but not more than 10	Greater than 0.5 mSv/h (50 mrem/h) but less than or equal to 2 mSv/h (200 mrem/h)	YELLOW-III
More than 10	Greater than 2 mSv/h (200 mrem/h) but less than or equal to 10 mSv/h (1,000 mrem/h)	YELLOW-III (Must be shipped under exclusive use provisions; see 173.441(b))

¹Any package containing a “highway route controlled quantity” (§173.403) must be labeled as RADIOACTIVE YELLOW-III.

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

The three radioactive labels are prescribed in §§ 172.436 - 440 and are shown in Figure 21.

Figure 21 - Radioactive Material Labels



WHITE-I Label YELLOW-II Label YELLOW-III Label

For each of these labels, the vertical bars following RADIOACTIVE are in red. Each label is diamond-shaped, at least 100 mm (3.9 inches) on each side. The background color of the upper half (within the black line) is white for the “I” label. It is yellow for the “II” and “III” labels. Other label specifications are given in § 172.407.

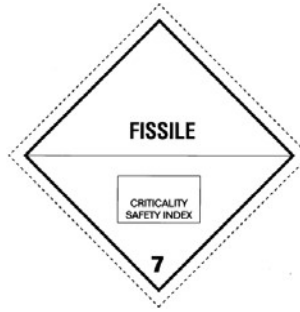
The following applicable items of information must be entered on the blank spaces of each radioactive label by legible printing (manual or mechanical) using a durable, weather-resistant means of marking:

- Contents – Except for LSA-I material, the names of the radionuclides. For mixtures of radionuclides, the radionuclides that represent 95% of the hazard present as determined in accordance with § 173.433(g) are listed. For LSA-I material, the term “LSA-I” may be used in place of the names of the radionuclides.
- Activity – Activity must be expressed in appropriate SI units (e.g., becquerels (Bq), terabecquerels (TBq), etc.). Except for plutonium-239 and plutonium-241, the weight in grams or kilograms of fissile radionuclides may be inserted instead of activity units. For plutonium-239 and plutonium-241, the weight in grams of fissile radionuclides may be inserted in addition to the activity units.
- Transport Index (TI) on Yellow-II and Yellow-III labels (not on White-I)

For radioactive materials with subsidiary hazards, the required subsidiary labels must also be applied.

For fissile material packages, a FISSILE label with the CSI indicated is required. Two fissile labels must be placed adjacent to the two radioactive material labels on the package. The fissile label is specified in § 172.441 and shown in Figure 22.

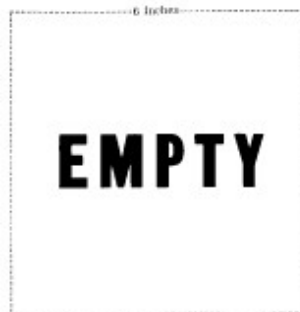
Figure 22 - Fissile Label



Each such FISSILE 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 § 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.)

Empty radioactive material packages shipped under § 173.428 must be labeled with the “Empty” label specified in § 172.450 (shown in Figure 23) and have any other affixed labels removed or obliterated.

Figure 23 - Empty Label



The radioactive labels alert persons, particularly cargo handlers, that the package contains radioactive material and that the package may require special handling and stowage distance/separation control. A WHITE-I label indicates that the external radiation level is low and no special stowage controls or handling are required. The YELLOW-II and YELLOW-III labels indicate that the package will have an external radiation level which requires consideration of stowage distance/separation control in transportation. If the package bears the fissile label, the material has properties relating to nuclear criticality safety and may also require stowage controls in transportation. If the package bears a YELLOW-III label, the transport vehicle must be placarded RADIOACTIVE by the carrier when the packages are accepted from a shipper.

F. Placarding Requirements

Section 172.504 requires a placard for a transport vehicle (rail or highway) if any radioactive material package bears the “RADIOACTIVE YELLOW-III” label. Placards are also required for domestic transportation of exclusive use shipments of LSA material (unless the material is unconcentrated U or Th ores) and SCO shipped in excepted packaging under § 173.427(b)(4); liquid LSA-I material; or unpackaged LSA material or SCO. Section 172.506 requires the shipper to provide the required placards to the motor carrier, unless the carrier's motor vehicle is already placarded as required. Section 172.508 requires shippers to affix placards to rail cars.

The RADIOACTIVE placard is specified in § 172.556 and is illustrated in Figure 24.

Figure 24 - Vehicle Radioactive Placard



The background color for the black trefoil symbol in the upper half of this 12” by 12” placard is yellow.

NOTE: In the case of foreign shipments coming into the U.S., the placard may take the format of an enlarged RADIOACTIVE label or may look slightly different with the yellow background extending to the middle of the placard, ending at a black line. Foreign placards may also have the UN identification number in place of the word RADIOACTIVE.

For highway shipments of highway route controlled quantity shipments, the placard must be presented with a white square background and a black border as shown in Figure 25.

Figure 25 - HRCQ Placard



Section 172.505(b) requires that UF₆ shipments containing 454 kg (1,001 lb) or more of UF₆ must display the CORROSIVE placard in addition to any required radioactive placarding.

G. Emergency Response Information Requirements

Section 172.600 requires shippers to provide emergency response information on hazardous materials shipments. The regulation applies to any shipment of a hazardous material which is required to have shipping papers. Shipments of excepted radioactive material packages (packages containing limited quantities, instruments or articles, or “Empty” packagings) are excepted from shipping paper requirements, and, therefore, are not subject to the emergency response information requirements unless they contain a hazardous substance.

1. Required Information

At a minimum, the emergency response information must provide: the basic description and technical name of the hazardous material, immediate hazards to health, immediate precautions to be taken in the event of an accident or incident, immediate methods for handling fires, immediate methods for handling spills or leaks in the absence of fire, and preliminary first aid measures.

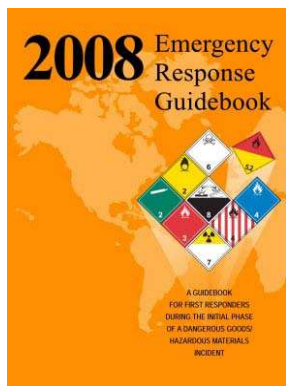
This information must be on a shipping paper or an associated document and kept on the vehicle and maintained at all locations where the shipment is handled. This required information is very similar to the information in the guide pages of the Emergency Response Guidebook (ERG) (see Section 3 below). In many cases, shippers satisfy this requirement by attaching to their shipping papers an appropriate guide page from the ERG.

There is a wide range of potential hazards for the many types of radioactive material that can be shipped under a given shipping name and guide number. If the product being shipped has properties that are either less hazardous or more hazardous than the description in the applicable guide in the ERG, then the emergency actions could be more specific than those in the guide. In such cases, the shipper may wish to satisfy the technical information requirements from § 172.602 (a)(1-7) by preparing statements that are appropriate to the product being shipped.

2. Emergency Response Telephone Number

Shippers are required to provide an emergency response telephone number which must be monitored on a 24-hour basis while the shipment is in transportation. The number must be of a person or entity who is knowledgeable of mitigation information or has immediate access to such a person. If the number of the agency hired to provide the information is listed, the person offering the shipment must ensure the agency has received the most current information on the material and that it accepts responsibility for providing this information in an emergency.

3. Emergency Response Guidebook



The Emergency Response Guidebook (ERG2008) was developed jointly by the US Department of Transportation, Transport Canada, and the Secretariat of Communications and Transportation of Mexico (SCT) for use by firefighters, police, and other emergency services personnel who may be the first to arrive at the scene of a transportation incident involving a hazardous material. It is primarily a guide to aid first responders in (1) quickly identifying the specific or generic classification of the material(s) involved in the incident, and (2) protecting themselves and the general public during this initial response phase of the incident. DOT's goal is to place one ERG2008 in each emergency service vehicle, nationwide, through distribution to state and local public safety authorities. The ERG may be found online at: <http://hazmat.dot.gov/pubs/erg/guidebook.htm> and at <http://www.tc.gc.ca/canutec/en/guide/guide.htm>.

The Guidebook is divided into color-coded sections: white, yellow, blue, orange and green. Information on how to use the Emergency Response Guidebook and other supporting information can be found in the white pages. The yellow-bordered pages index the list of dangerous goods in numerical order of 4-digit ID number. The blue bordered pages index the list of dangerous goods in alphabetical order by material name. The green-bordered pages suggest initial isolation distances and protective action distances for hazardous material spills that are Toxic by Inhalation (TIH). A list of gases produced when spilled in water is also provided. Both the yellow and blue pages lead you to a guide number located in the orange bordered pages. The orange-bordered pages (orange guides) are most important as this is where all the safety recommendations reside. The orange pages comprise a total of 62 individual guides, each providing safety recommendations and emergency response information to protect first responders and the public. Recommendations include potential hazards, public safety, and emergency response actions.

The orange guides 161- 166 provide information on radioactive material incidents. These guides are titled as follows:

- Guide 161 - Radioactive Materials (Low Level Radiation)
- Guide 162 - Radioactive Materials (Low to Moderate Level Radiation)
- Guide 163 - Radioactive Materials (Low to High Level Radiation)
- Guide 164 - Radioactive Materials (Special Form/Low to High Level External Radiation)
- Guide 165 - Radioactive Materials (Fissile/Low to High Level Radiation)
- Guide 166 - Radioactive Materials – Corrosive (Uranium Hexafluoride/Water-Sensitive).

H. Training Requirements

Training requirements are found in several sections of the HMR as follows:

- General - § 173.1
- Specific - § 172.704
- Modal:
 - Air - § 175.20
 - Vessel - § 176.13
 - Highway - §§ 177.800, 177.816

DOT has information and reference materials for training requirements at: <http://hazmat.dot.gov/training/training.htm>.

Section 172.704 requires that each *hazmat employer* must ensure that each *hazmat employee*, as defined in § 171.8, receives the required training and testing in the following subjects:

- General awareness/familiarization with the 49 CFR hazardous materials transportation requirements
- Function-specific training
- Safety training
- Security awareness training
- In-depth security training, if a security plan is required.

Initial training is required within 90 days of employment on a specific job. The hazmat employee must have **recurrent training** every three years or within 90 days after assignment to a new job for which training has not already been provided.

1. **General Awareness/Familiarization Training**

General awareness/familiarization training is directed toward the hazmat employee being able to recognize and identify hazardous materials in a manner consistent with the hazard communication standards of 49 CFR 172. Training in this area should include a basic orientation on DOT shipping papers, package marking, package labeling, emergency response information and vehicle placarding requirements. Testing should focus on awareness, recognition and identification. DOT has prepared training modules that meet the requirements for general awareness training which may be found at <http://hazmat.dot.gov/training/mods/mod.htm>.

2. **Function-Specific Training**

Function-specific training is intended to focus on those hazardous material activities (functions) which actually involve the hazmat employee. If the employee does not perform certain hazmat activities, then neither training nor testing in those activities is required.

3. **Safety Training**

Safety training must cover the following:

- Required emergency response information
- Measures to protect the employee from hazards
- Methods and procedures for avoiding accidents, such as proper handling procedures

OSHA Safety training may be used to satisfy this requirement.

4. **Security Awareness Training**

Security awareness training is to provide an awareness of security risks associated with hazardous materials transportation and methods designed to enhance transportation security. This training must also include a component covering how to recognize and respond to possible security threats.

5. In-Depth Security Training

Each hazmat employee of a company required to have a security plan in accordance with § 172.800 (see Section I below) must be trained concerning the security plan and its implementation. Security training must include company security objectives, specific security procedures, employee responsibilities, actions to take in the event of a security breach, and the organizational security structure.

6. Testing and Record Keeping

Each hazmat employee must be trained and tested to determine the effectiveness of the training received. The hazmat employer must certify that each hazmat employee has been properly trained, and the employer must maintain the training records for hazmat employees. Training Records must include:

- Hazmat employee's name;
- Completion date of most recent training;
- Training Materials (Copy, description, or location);
- Name and address of hazmat trainer; and
- Certification that the hazmat employee has been trained and tested

I. Security Requirements

Title 49 CFR Part 172, Sections 800-804, establishes the requirements for the development and implementation of security plans for shippers and carriers of specified high-risk hazardous materials. Security plans are required for those who offer for transportation the following types and quantities of hazardous materials:

- A hazardous material in an amount that must be placarded in accordance with Subpart F of Part 172 of the HMR;
- A hazardous material in a bulk packaging having a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases or more than 13.24 cubic meters (468 cubic feet) for solids; or
- A select agent or toxin regulated by the Centers for Disease Control and Prevention under 42 CFR Part 73.
- OSHA safety training may be used to satisfy this requirement.

A security plan must include an assessment of possible transportation security risks for shipments of the hazardous materials covered by the plan and appropriate measures to address the assessed risks. At a minimum, a security plan must include the following elements:

- Personnel security. Measures to confirm information provided by job applicants hired for positions that involve access to and handling of the hazardous materials covered by the security plan.
- Unauthorized access. Measures to address the possibility that unauthorized persons may gain access to the hazardous materials covered by the security plan or to transport conveyances being prepared for transportation of the hazardous materials covered by the security plan.
- En route security. Measures to address the security risks of shipments of hazardous materials covered by the security plan en route from origin to destination, including shipments stored incidental to movement.

Additional information and resources for hazardous materials security can be found at the DOT website:

http://hazmat.dot.gov/riskmgmt/hmt/hmt_security.htm

J. Incident Reporting Requirements

Incident reporting requirements are given in §§ 171.15 and 171.16. Two phases of incident reporting are required in the regulations; § 171.15 covers immediate telephone notification following an incident and § 171.16 outlines written reporting procedures within 30 days.

Section 171.15 requires notification, as soon as practical, but no later than 12 hours after the occurrence, of any reportable incident that occurs during the course of transportation in commerce (including loading, unloading, and temporary storage). Any reporting delay beyond what is necessary to safely secure the incident scene is not permitted. Notification must be made by telephone to the National Response Center on 800-424-8802 (toll free) or 202-267-2675 (toll call). Included in the list of reportable incidents is the following:

- Fire, breakage, spillage, or suspected radioactive contamination occurs involving a radioactive material.

For reportable incidents that require immediate notification, and for some other occurrences, such as the discovery of undeclared hazardous material, § 171.16 requires submittal of a Hazardous Materials Incident Report on DOT Form F 5800.1 (01/2004) within 30 days of discovery of the incident. Reports must be provided to the Information Systems Manager, PHH-63, Pipeline and Hazardous Materials Safety Administration, Department of Transportation, Washington, DC 20590- 0001, or an electronic Hazardous Material Incident Report may be filed online at <https://hazmatonline.phmsa.dot.gov/incident/>. For an incident involving transportation by aircraft, a written or electronic copy of the Hazardous Materials Incident Report must be sent to the FAA Security Field Office nearest the location of the incident.

A copy of the Hazardous Materials Incident Report must be retained for a period of two years. In addition, a Hazardous Materials Incident Report must be updated within one year of the date of occurrence of the incident in certain instances.

Further information on incident reporting requirements may be found at <http://hazmat.dot.gov/enforce/spills/spills.htm>.

IX. QUALITY ASSURANCE

DOT requirements for quality control are located in §§ 173.474 and 173.475. These are titled “Quality control for construction of packaging” and “Quality control requirements prior to each shipment of Class 7 (radioactive) materials”, respectively. (The NRC regulations in 10 CFR Part 71 contain similar requirements in paragraphs §§71.85 and 71.87, entitled “Preliminary Determinations” and “Routine Determinations”, respectively).

A. Prior to First Use

Section 173.474 requires that prior to the first use of any packaging for the shipment of Class 7 (radioactive) material, the offeror shall determine that:

- The packaging meets the quality of design and construction requirements as specified in the HMR; and
- 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.

B. Prior to Each Use

Section 173.475 requires that prior to each shipment of Class 7 (radioactive) materials, the offeror must ensure, by examination or appropriate tests, that:

- The packaging is proper for the contents to be shipped;
- The packaging is in unimpaired physical condition, except for superficial marks;
- Each closure device of the packaging, including any required gasket, is properly installed, secured, and free of defects;
- For fissile material, each moderator and neutron absorber, if required, is present and in proper condition;
- Each special instruction for filling, closing, and preparation of the packaging for shipment has been followed;

- Each closure, valve, or other opening of the containment system through which the radioactive content might escape is properly closed and sealed;
- Each packaging containing liquid in excess of an A₂ quantity and intended for air shipment has been tested to show that it will not leak under an ambient atmospheric pressure of not more than 25 kPa, absolute (3.6 psia). The test must be conducted on the entire containment system, or on any receptacle or vessel within the containment system, to determine compliance with this requirement;
- The internal pressure of the containment system will not exceed the design pressure during transportation; and
- External radiation and contamination levels are within the allowable limits specified in this subchapter.

This last requirement to ensure compliance with radiation and contamination limits of §§ 173.441 and 173.443 does **not** require that surveys or direct measurement be made. Both sections give shippers latitude in their methods of ensuring compliance with the radiation and contamination limits; procedures other than measurements, such as quality assurance and quality control, are acceptable means of ensuring compliance. However, if a compliance inspection during transportation determines that radiation or contamination levels exceed the limit, the shipper is subject to a citation.

C. NRC QA Requirements

In addition to the above-mentioned generic quality control requirements of 10 CFR 71.85 and 71.87, 10 CFR 71, Subpart H, contains specific quality assurance (QA) requirements associated with the use of NRC-certified Type B and fissile material packages used under the general licenses of §§ 71.17, 71.20, and 71.21. A major condition applying to the use of such NRC-certified packages is the requirement that each registered user of such a package must have their quality assurance program, associated with use of the package, approved by the NRC as having met applicable requirements of Subpart H, §§ 71.101-71.137. Section 71.37(a) requires that applicants requesting package design approval by the NRC must describe, with respect to Subpart H of 10 CFR Part 71, the QA programs that they will apply in designing, fabricating, assembling, testing, maintaining, repairing, modifying, and using the proposed packaging.

NRC's Regulatory Guide 7.10, "Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material" provides guidance on developing quality assurance programs and guidance for preparing and submitting QA program descriptions for review by the NRC.

X. OVERVIEW OF NRC'S 10 CFR TRANSPORT-RELATED REQUIREMENTS

Transportation requirements of NRC which apply to transport of NRC-licensed radioactive material are located in 10 CFR 71. Since 10 CFR part 71 is a matter of “compatibility” for regulatory programs of the NRC “Agreement States,” effectively it is also applicable to activities of Agreement State licensees. Several other transport-related requirements are in 10 CFR Part 20. A brief overview of these follows.

NOTE: NRC and Agreement States regulate licensed shippers and receivers of radioactive material packages, not carriers. DOT's authority applies to shippers and carriers, not to receivers.

A. 10 CFR PART 71

In accordance with 10 CFR 71.5, each NRC licensee who transports licensed radioactive material outside the site of usage, as specified in the NRC license, or where transport is on a public highway, or who delivers licensed material to a carrier for transport, must comply with the applicable requirements of the DOT hazardous materials transport regulations. NRC inspects the radioactive material shipping practices of its licensees, and enforces licensee compliance with the DOT regulations.

With the exception of packages approved by the U.S. Department of Energy (DOE), all packages used for domestic shipments of fissile material (in excess of fissile exempt quantity) and for quantities of other licensed material in excess of Type A quantities must be certified for use by the NRC. The user must register with the NRC and make all shipments in compliance with the terms of the package approval. The package approval standards and performance requirements are set out in 10 CFR 71.

NRC has published Regulatory Guide 7.9, “Standard Format and Content of Part 71 Applications for Approval of Packages for Radioactive Material” to assist applicants in preparing applications that thoroughly and completely demonstrate the ability of the given packages to meet the regulations. NRC’s “Standard Review Plan for Transportation Packages for Radioactive Material” (NUREG-1609) provides 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. The “Standard Review Plan for Transportation Packages for Spent Nuclear Fuel” (NUREG -1617) provides guidance for the review and approval of applications for packages used to transport spent nuclear fuel under 10 CFR Part 71.

B. 10 CFR PART 20

This Part has transportation-related requirements in 10 CFR §§ 20.1906 and 10 CFR 20.1601(e), and in Appendix G.

1. Procedures for Receiving and Opening Packages

10 CFR § 20.1906 covers procedures for receiving and opening packages. Each licensee who expects to receive a package containing quantities of radioactive material in excess of a Type A quantity shall make arrangements to receive:

- The package when the carrier offers it for delivery; or
- Notification of the arrival of the package at the carrier's terminal and to take possession of the package expeditiously.

This section also requires that an NRC licensee who receives a radioactive package perform certain monitoring of the package, as follows:

- Except for packages containing gaseous or special form radioactive material, any package bearing any of the three categories of RADIOACTIVE labels must be monitored for **external surface contamination**;
- The external surface of any package containing greater than a Type A quantity, (i.e., a Type B quantity) must be monitored upon receipt for **external radiation levels**;
- Monitoring for both surface contamination and external radiation levels must be performed on any package known to contain radioactive material, **if there is evidence of degradation of package integrity** (such as packages that are crushed, wet, or damaged);

The licensee shall perform the required monitoring as soon as practical after receipt of the package, but not later than 3 hours after the package is received at the licensee's facility (if it is received during the licensee's normal working hours, or not later than 3 hours from the beginning of the next working day if it is received after working hours).

Instances of surface contamination and/or external radiation levels exceeding the applicable limits **must be reported immediately to the appropriate NRC regional office.**

Each licensee must:

- Establish, maintain, and retain written procedures for safely opening packages in which radioactive material is received; and
- Ensure that the procedures are followed and that due consideration is given to special instructions for the type of package being opened.

2. Control Of Access To High Radiation Areas Containing Radioactive Material Packages

10 CFR 20.1601 “Control of access to high radiation areas” paragraph (e) reads as follows:

“Control is not required for each entrance or access point to a room or other area that is a high radiation area solely because of the presence of radioactive material prepared for transport and labeled in accordance with the regulations of the Department of Transportation provided that:

- (1) The packages do not remain in the area longer than 3 days; and
- (2) The dose rate at one meter from the external surface of any package does not exceed 0.01 rem (0.1 mSv) per hour.”

In implementing the provisions of Section 20.1601(e), it is apparent that time is of the essence for package storage (not more than 3 days) and no package may have a TI greater than ten.

3. Requirements for Transfers of Low-Level Radioactive Waste

10 CFR 20, Appendix G, covers requirements for transfers of low-level radioactive waste intended for disposal at licensed land disposal facilities and for low-level waste manifests. It requires a waste generator, collector, or processor who transports, or offers for transportation, low-level radioactive waste intended for ultimate disposal at a licensed low-level radioactive waste land disposal facility to prepare a Manifest (OMB Control Numbers 3150-0164, -0165, and -0166) reflecting information requested on applicable NRC forms including Form 540 (Uniform Low-Level Radioactive Waste Manifest (Shipping Paper)). NRC Form 540 contains information needed to satisfy DOT shipping paper requirements in 49 CFR Part 172 and the waste tracking requirements of 10 CFR Part 20. The current revision of Form 540 can be found at <http://www.nrc.gov/reading-rm/doc-collections/forms/>. The instructions for completing Form 540 are contained in NRC document NUREG/BR-0204 available at the NRC web site at: <http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0204/>

C. Notification Requirements

The NRC regulations in 10 CFR 71.97 and 10 CFR 73.72 require that licensees shipping HRCQ of nuclear waste in Type B packages, spent nuclear fuel, and special nuclear materials provide advance notification to state governors or their designated representative.

D. NRC Requirements for Radioactive Materials in Quantities of Concern

As part of the NRC's efforts to improve radioactive material security after the events of September 11, 2001, the NRC requires additional security measures when an individual and/or company is engaged in certain NRC-licensed activities. These additional security measures include advance notification to the NRC and state governors or their designated representatives about certain radioactive material shipments. The individuals and/or companies engaged in NRC-licensed activities were issued these security measures through a modification of their NRC license and they are cognizant of its specific requirements.

XI. OTHER REQUIREMENTS

A. Carrier Requirements

There are two types of motor carriers, private carriers and for-hire carriers. A private carrier is a company that provides truck transportation of its own cargo, usually as a part of a business that produces, uses, sells and/or buys the cargo being hauled. A for-hire carrier is a company that provides truck transportation of cargo belonging to others and is paid for doing so. For radioactive material, for-hire carriers are exempt from the requirement to obtain a license from NRC or an Agreement State, to the extent that they transport licensed radioactive material for someone else (see 10 CFR §§ 30.13, 40.12 and 70.12). A private carrier generally owns the radioactive material which is being transported and transportation activities are incidental to their regular business activity. A private carrier is always licensed by the NRC or an agreement state to possess and transport the radioactive material.

All carriers are subject to the same safety requirements of the HMR. An exception from the requirement for **certification** of the shipping papers is provided to a private carrier (see §172.204(b)(1)(ii)).

The principal requirements which apply to all carriers are to:

- Assure that the transport vehicle is properly placarded;
- Assure that shipper has properly certified the shipment;
- Maintain radiation control based on package transport index/separation table and the other transport requirements;
- Report to DOT hazmat incidents involving fire, accident, breakage or suspected radioactive contamination (§§ 171.15, 171.16, 174.750, 175.705(e), 176.710(c), and 177.843(c));
- Provide training to “Hazmat Employees”;
- Develop security plans as required by 49 CFR Part 172, §§ 800-804; and
- Register with DOT and submit an annual fee when transporting certain radioactive material.

The sections specifically applicable to radioactive material in the modal parts of the HMR begin at the following sections:

- Rail § 174.700;
- Air § 175.700 (also see §§ 175.33 and 175.75);
- Water § 176.700; and
- Highway §§ 177.842, 177.843, and 177.870(g).

Some of the requirements in these areas have been described above in the sections on Transport Controls and Hazmat Communications and Related Requirements.

B. Registration Requirements

DOT has a national registration program for certain persons engaged in offering for transport and transporting of certain hazardous materials in foreign, interstate or intrastate commerce. The registration requirement (found in §§ 107.601 - 107.620) applies to radioactive material **shippers or carriers** who **offer or transport**:

- Shipments of a “Highway Route Controlled Quantity”;
- Shipments of radioactive material in bulk packaging with a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases, or more than 13.24 cubic meters (468 cubic feet) for solids; or
- Shipments of radioactive material for which vehicle placarding is required, which includes:
 - Domestic transportation of exclusive use shipments of less than an A₂ quantity of LSA material (unless the material is unconcentrated U or Th ores) and SCO shipped in excepted packaging under § 173.427(b)(4); liquid LSA-I material; or unpackaged LSA material or SCO.
 - Shipments of packages bearing RADIOACTIVE-YELLOW III labels, whether in an exclusive or non-exclusive use vehicle.

The registration fee is \$1000 annually (\$275 for small businesses and not-for-profit organizations) (§ 107.612). The fee provides funds for grants distributed to States and Indian tribes for hazardous materials emergency response planning and training. This program began in 1992 and is administered by the Associate Administrator for Hazardous Materials Safety, Pipeline and Hazardous Materials Safety Administration (PHMSA).

Information on the registration program may be found online at <http://hazmat.dot.gov/regs/register/register.htm>.

C. Motor Carrier Safety Requirements

Besides the transportation controls in §§ 177.842, 177.843, and 177.870(g), highway shipments may be subject to the Federal Motor Carrier Safety Regulations (FMCSR) which are located in 49 CFR Parts 350-399. The FMCSR apply if the vehicle has a gross vehicle weight rating of 10,001 pounds or more, or if the radioactive material is being transported in a quantity requiring placarding. For intrastate commerce, a state may impose some requirements different than the FMCSR.

Some of the FMCSR requirements of particular relevance to radioactive materials shipments are those for commercial driver's license with hazardous materials endorsement, Hazardous Materials Safety Permits, and routing requirements.

1. Commercial Driver's License

A "Commercial Driver's License" (CDL) means a license issued to an individual by a state or other jurisdiction, in accordance with the standards in 49 CFR Part 383, which authorizes that individual to operate a "commercial motor vehicle". For radioactive material shipments the driver of a vehicle that requires placarding must have a CDL with a "hazardous materials endorsement" (§ 383.93).

In order to obtain a hazardous materials endorsement, each applicant must pass a test demonstrating knowledge of the following (see § 383.121):

- Hazardous materials regulations,
- Hazardous materials handling,
- Operation of emergency equipment, and
- Emergency response procedures.

A State may not issue, renew, upgrade, or transfer a hazardous materials endorsement for a CDL to any individual authorizing that individual to operate a commercial motor vehicle transporting a hazardous material in commerce unless the Transportation Security Administration (TSA) has determined that the individual does not pose a security risk warranting denial of the endorsement.

2. **Hazardous Materials Safety Permits**

The Federal Motor Carrier Safety Administration (FMCSA) requires motor carriers to obtain a Hazardous Materials Safety Permit (HMSP) prior to transporting certain highly hazardous materials, including a highway route controlled quantity of a Class 7 (radioactive) material. All motor carriers, including interstate, intrastate and foreign carriers must comply with this regulation. In order to maintain an HMSP, motor carriers are required to:

- Maintain a “satisfactory” safety rating in order to obtain and hold a safety permit.
- Maintain their crash rating, and their driver, vehicle, hazardous materials or out-of service rating so they are not in the worse 30 percent of the national average as indicated in FMCSA's Motor Carrier Management Information System (MCMIS).
- Have a satisfactory security program (and associated training) according to § 172.800 in place.
- Maintain registration (see above) with PHMSA.
- Develop a system of communication that will enable the vehicle operator to contact the motor carrier during the course of transportation and maintain records of these communications.
- Have a written route plan required for radioactive materials set forth in § 397.101 and for explosives in Part 397.19.
- Perform a pre-trip inspection (North American Standard (NAS) Level VI Inspection Program for Radioactive Shipments) for shipments containing highway route controlled Class 7 (radioactive) materials.

The pre-trip inspection required in 49 CFR § 385.415 for HRCQ shipments must be performed by a Federal, State, or local government inspector, or an inspector under contract with a Federal, State, or local government. The inspector must have completed an appropriate training program of at least 104 hours, including at least 24 hours of training in conducting radiological surveys on inspecting vehicles transporting highway route controlled quantity (HRCQ) radioactive materials.

The inspection must cover all applicable requirements in the HMR and the FMCSR--including 49 CFR Parts 383 (commercial driver's license), 391 (driver qualifications), 395 (hours of service), 393 and 396 (vehicle condition)--or compatible State regulations; and provisions in the HMR on the transportation of radioactive materials (49 CFR Parts 171, 172, 173 and 178) and registration (49 CFR Part 107, Subpart G).

The requirements for the HMSP may be found in 49 CFR §§ 385.401- 423 and online at www.fmcsa.dot.gov/safetyprogs/hm.htm.

3. **Highway Routing Requirements**

The requirements for the routing of radioactive material shipments by highway are in 49 CFR § 397.101 – 397.103.

A carrier or any person operating a motor vehicle that contains a class 7 (radioactive) material as defined in 49 CFR § 173.403 for which placarding is required under 49 CFR Part 172 shall ensure that the motor vehicle is operated on routes that minimize radiological risk and shall tell the driver which route to take and that the motor vehicle contains radioactive materials (49 CFR § 397.101(a)).

If the contents of a package being shipped are a highway route controlled quantity, the package must be transported under specific routing controls as given in 49 CFR § 397.101(b):

- The carrier must operate on “preferred routes”.
(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 §397.103, or both. The “Guidelines for Selecting Preferred Highway Route Controlled Quantity Shipments of Radioactive Materials” describe the guidelines for States to use in designating routes; it may be found online at <http://hazmat.fmcsa.dot.gov/nhmrr/PDFs/ramguide.pdf>. The State-designated routes may be found at: <http://hazmat.fmcsa.dot.gov/nhmrr/index.asp>.)
- The carrier shall select routes to reduce time in transit over the preferred route segment of the trip.
- Interstate System bypass beltway around a city, when available, shall be used in place of a preferred route through a city.
- Deviations from preferred routes are allowed only:
 - As necessary to pick up or deliver HRCQ
 - To make necessary rest, fuel or motor vehicle repair stops, or
 - Under emergency conditions.
- Pickup and delivery segments of the route are to follow:
 - Shortest-distance route from the pickup/delivery location to the nearest preferred route entry/exit location
 - Deviation from the shortest-distance pickup or delivery route is authorized if such deviation:
 - Minimizes the radiological risk;
 - Does not exceed the shortest-distance route by more than 25 miles and
 - Does not exceed five times the length of the shortest-distance route.

- The carrier is required to prepare a written route plan and furnish a copy to the driver and the shipper (before departure for exclusive use shipments and within 15 days following departure for all other shipments).
- Carriers of highway route controlled quantities must also file detailed reports to the Office of Enforcement and Compliance (MC-PSDECH), Federal Motor Carrier Safety Administration, within 90 days of accepting the packages for shipment. The report must include the route plans, shipping papers, names of shippers, carriers and consignees, etc. (Reference 49 CFR § 397.101(g).) *NOTE: Shipments made in compliance with the physical security requirements of 10 CFR Part 73 of the NRC are excepted from this requirement.*
- The driver of a shipment with highway route controlled quantities must be provided with certain training every two years and must have in his possession a certificate of such training.

D. Radioactive Material Shipments By Air

As noted in Section III above, the HMR authorizes air transport of radioactive material in accordance with the ICAO Technical Instructions provided all of the conditions of § 171.22 are met.

Section 175.700 limits Class 7 materials aboard a passenger-carrying aircraft to excepted packages, unless the material is intended for use in, or incident to research, medical diagnosis or treatment. Regardless of its intended use, no person may carry a Type B(M) package aboard a passenger-carrying aircraft, a vented Type B(M) package aboard any aircraft, or a liquid pyrophoric Class 7 material aboard any aircraft.

NRC requirements in 10 CFR § 71.88 limit the air transport of plutonium.

XII. DOT AND NRC ENFORCEMENT POLICIES

Under the DOT/NRC MOU, each agency conducts an inspection and enforcement program within its jurisdiction to assure compliance with its requirements. The NRC will normally carry out enforcement actions for violations of the requirements of 10 CFR Part 71 and 49 CFR (except 49 CFR Parts 390-397) by NRC licensee-shippers and licensee-shipper-private carriers. The DOT will carry out enforcement actions for violations of 49 CFR (including Parts 390-397) by carriers of radioactive materials and shippers of radioactive materials from agreement states, DOE contractors, or any other shippers otherwise not subject to NRC requirements.

Violations of the regulations in 49 CFR and 10 CFR Part 71 may result in civil or criminal penalties, cease/desist orders, suspension orders, etc. DOT's enforcement powers under the HMR are explained in 49 CFR Subpart D. Further information on enforcement of the HMR may be found at <http://hazmat.dot.gov/enforce/hmenforce.htm>. NRC's "Enforcement Policy" may be found on the NRC public web site and the NRC Agency-wide Document Access and Management System (ADAMS) (see <http://www.nrc.gov/about-nrc/regulatory/enforcement.html>).

Import and export shipments must be made in accordance with the international regulations that are cited in §§ 171.12 and 171.22. When import shipments are found to be in violation of the international air and sea transport regulations (which are essentially the same as the IAEA regulations) enforcement action against the foreign shipper or carrier can be taken by DOT by citing the applicable requirements in the ICAO or IMO regulations. If violations are found in radioactive material shipments being exported under the IMO or ICAO, the shipper or carrier may be charged with violating both the domestic and the international regulations.

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APPENDIX A INTERNATIONAL SYSTEM OF UNITS (SI) FOR RADIOACTIVE MATERIALS IN TRANSPORTATION

The information contained in this appendix is intended to aid persons in understanding the relationships between the International System of Units (SI) and the customary units for radiological measurements. It is designed to help in converting values shown in one system to values in the other system.

To ensure compatibility with international transportation standards, units of measure in the HMR are expressed using SI units. U.S. standard or customary units, which appear in parentheses following the SI units, are for information only and are not intended to be the regulatory standard.

The labels on packages and descriptive information on shipping documents show the measure of the radioactive content or the activity. The SI unit used to measure activity is the becquerel (Bq); the customary unit is the curie (Ci). The maximum radiation level at 1 meter from a package determines the transport index (TI), which is shown on labels and shipping papers. The SI unit of measurement for radiation levels is the sievert (Sv) per hour; traditionally, it has been the rem (or a fraction of the rem) per hour.

It is often necessary to use numerical abbreviations to write the measured values in a practical way. The following pages provide definitions and abbreviations for numerical factors and for the customary and SI units. Additionally, examples of conversions from customary units to SI radiological and SI to customary units are detailed.

DEFINITIONS AND ABBREVIATIONS

NUMERICAL

Multiplication Factors	Prefix	Symbol
1 000 000 000 000 000 000 =	10^{18}	exa E
1 000 000 000 000 000 =	10^{15}	peta P
1 000 000 000 000 =	10^{12}	tera T
1 000 000 000 =	10^9	giga G
1 000 000 =	10^6	mega M
1 000 =	10^3	kilo k
100 =	10^2	hecto h
10 =	10^1	deka da
0.1 =	10^{-1}	deci d
0.01 =	10^{-2}	centi c
0.001 =	10^{-3}	milli m
0.000 001 =	10^{-6}	micro u (or μ)
0.000 000 001 =	10^{-9}	nano n
0.000 000 000 001 =	10^{-12}	pico p
0.000 000 000 000 001 =	10^{-15}	femto f
0.000 000 000 000 000 001 =	10^{-18}	atto a

RADIOLOGICAL

The curie and becquerel are units of measure of the quantity or activity of radioactive material which indicate the rate that atoms in the material are giving off radiation or disintegrating. The curie (Ci) is equal to 37 billion disintegrations per second, while the becquerel (Bq) is equal to only one disintegration per second. Thus, one curie is equal to 37 gigabecquerels or 0.037 terabecquerels; in symbols, $1 \text{ Ci} = 37 \text{ GBq} = 0.037 \text{ TBq}$.

The sievert (Sv) and the rem are units of radiation dose (technically, of dose equivalent) absorbed by the body. A sievert is equal to 100 rem, or $1 \text{ Sv} = 100 \text{ rem}$.

Another unit for activity is disintegrations per minute (dpm), which can be obtained from radiation detection instrumentation readouts in counts per minute (cpm) divided by the detector's system efficiency. Since curies are a measure of disintegrations per second (dps), they are related to dpm as follows:

$$1 \text{ curie (Ci)} = 3.7 \times 10^{10} \text{ dps} = 2.22 \times 10^{12} \text{ dpm}$$

$$1 \text{ millicurie(mCi)} = 3.7 \times 10^7 \text{ dps} = 2.22 \times 10^9 \text{ dpm}$$

$$1 \text{ microcurie } (\mu\text{Ci}) = 3.7 \times 10^4 \text{ dps} = 2.22 \times 10^6 \text{ dpm}$$

EQUIVALENTS FOR CONVERSIONS

Quantity (activity)

$$1 \text{ TBq} = 27 \text{ Ci} = 27,000 \text{ mCi}$$

$$1 \text{ GBq} = 0.027 \text{ Ci} = 27 \text{ mCi} = 27,000 \mu\text{Ci}$$

$$1 \text{ MBq} = 0.000027 \text{ Ci} = 0.027 \text{ mCi} = 27 \mu\text{Ci}$$

$$1 \text{ Ci} = 0.037 \text{ TBq} = 37 \text{ GBq} = 37,000 \text{ MBq}$$

$$1 \text{ mCi} = 0.000037 \text{ TBq} = 37 \text{ MBq}$$

$$1 \mu\text{Ci} = 0.037 \text{ MBq} = 37,000 \text{ Bq}$$

$$1 \text{ nCi} = 0.000037 \text{ MBq} = 37 \text{ Bq}$$

$$1 \text{ pCi} = 0.037 \text{ Bq} = 37 \text{ mB}$$

Radiation Level (dose equivalent rate)

$$1 \text{ Sv/h} = 100 \text{ rem/h} = 100,000 \text{ mrem/h}$$

$$1 \text{ mSv/h} = 0.1 \text{ rem/h} = 100 \text{ mrem/h}$$

$$1 \mu\text{Sv/h} = 0.0001 \text{ rem/h} = 0.1 \text{ mrem/h}$$

$$1 \text{ rem/h} = 0.01 \text{ Sv/h} = 10 \text{ mSv/h} = 10,000 \mu\text{Sv/h}$$

$$1 \text{ mrem/h} = 0.00001 \text{ Sv/h} = 0.01 \text{ mSv/h} = 10 \mu\text{Sv/h}$$

USE OF CONVERSION FACTORS

To convert a value from one system of units to the other:

- First, in the left column above, find the unit you wish to convert from.
- Second, find the factor in that line for the unit you wish to convert to.
- Third, multiply the original value by the factor; the result will be the measure in the desired units.

Examples:

1. A radioactive material label shows 14 TBq. How many curies is that?

$$14 \text{ TBq} \times 27 \text{ Ci per TBq} = 378 \text{ Ci}$$

2. There is 50 MBq of a radioactive material in a package. How many millicuries is it?

$$50 \text{ MBq} \times 0.027 \text{ mCi per MBq} = 1.35 \text{ mCi}$$

3. How many TBq are equal to 500 curies?

$$500 \text{ curies} \times 0.037 \text{ TBq per Ci} = 18.5 \text{ TBq}$$

4. The EPA standards require that public drinking water systems limit the natural radium concentration to less than 5 pCi per liter. What is this upper limit in becquerels?

$$5 \text{ pCi per liter} \times 0.037 \text{ Bq per pCi} = 0.185 \text{ Bq/liter}$$

5. The Transport Index (TI) of a package is the number equal to the maximum radiation level in millirem per hour at a distance of 1 meter from the package. A TI of 1.0 corresponds to a radiation level of 1 mrem/h at 1 meter. What is the radiation level in microsieverts per hour which corresponds to a TI of 2.5?

$$2.5 \text{ TI} \times 1.0 \text{ mrem/h per TI} \times 10 \text{ } \mu\text{Sv per mrem} = 25 \text{ } \mu\text{Sv/h}$$

6. The maximum surface radiation level for a package with a Radioactive Yellow-II label is 0.5 mSv per hour. Would a measured radiation level of 38 mrem per hour be acceptable for a Radioactive Yellow II label?
 $38 \text{ mrem/h} \times .01 \text{ mSv/h per mrem/h} = 0.38 \text{ mSv/h}$
Yes, since 0.38 mSv/h is less than 0.5 mSv per hour.