LA-UR-16-20656
Approved for public release; distribution is unlimited.

Title: Hazardous Material Packaging and Transportation

Author(s): Hypes, Philip A.

Intended for: Student Training

Issued: 2016-02-04

Hazardous Material Packaging and Transportation

Department of Energy
National Transportation
Program

LANL #30462 - Basic
Radioactive Material
Transportation

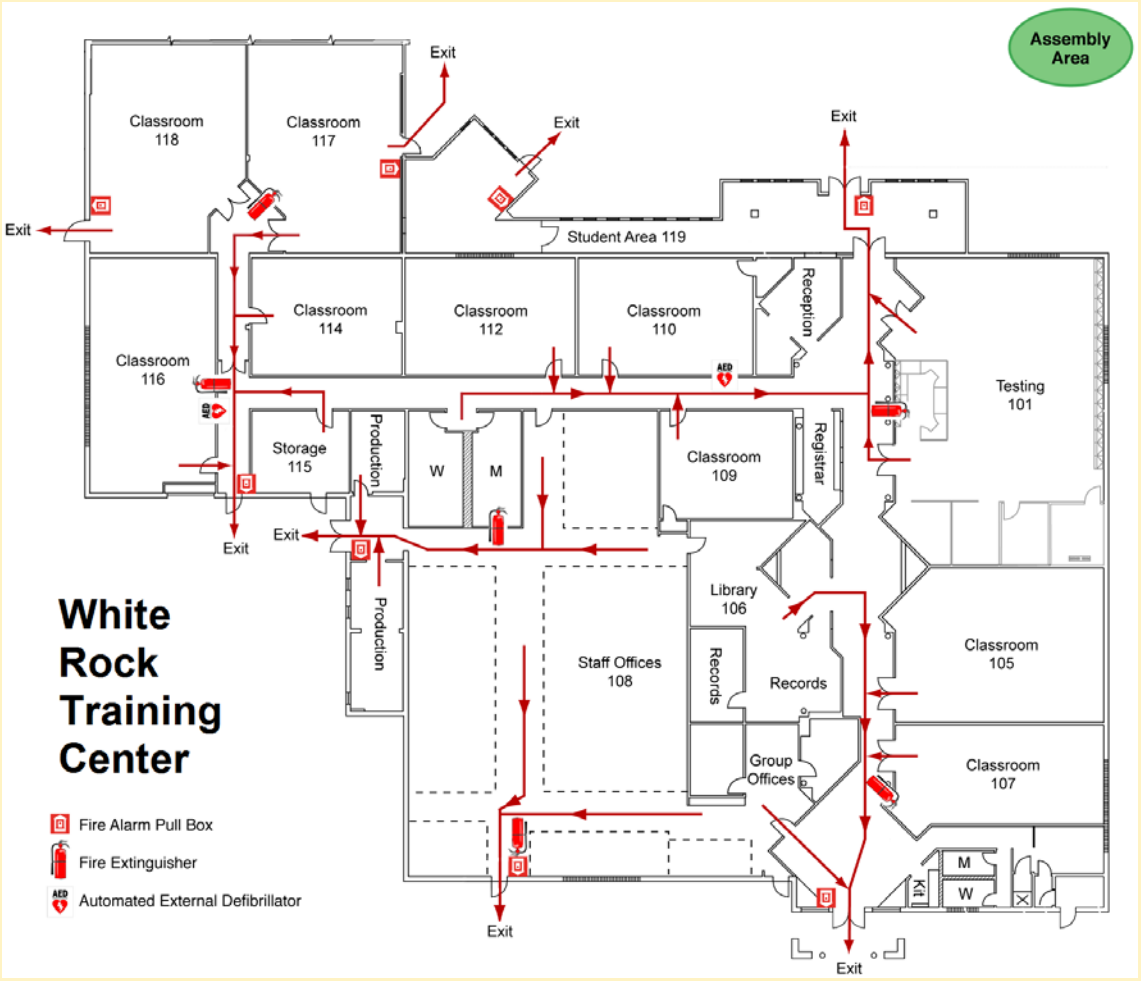
January 2016 – Part 1

Emergency Evacuation

- If an alarm sounds, evacuate the building and report immediately to the assembly area.

- Eating, drinking, and smoking are prohibited during evacuations and at the assembly area.

Emergency Exit Routes



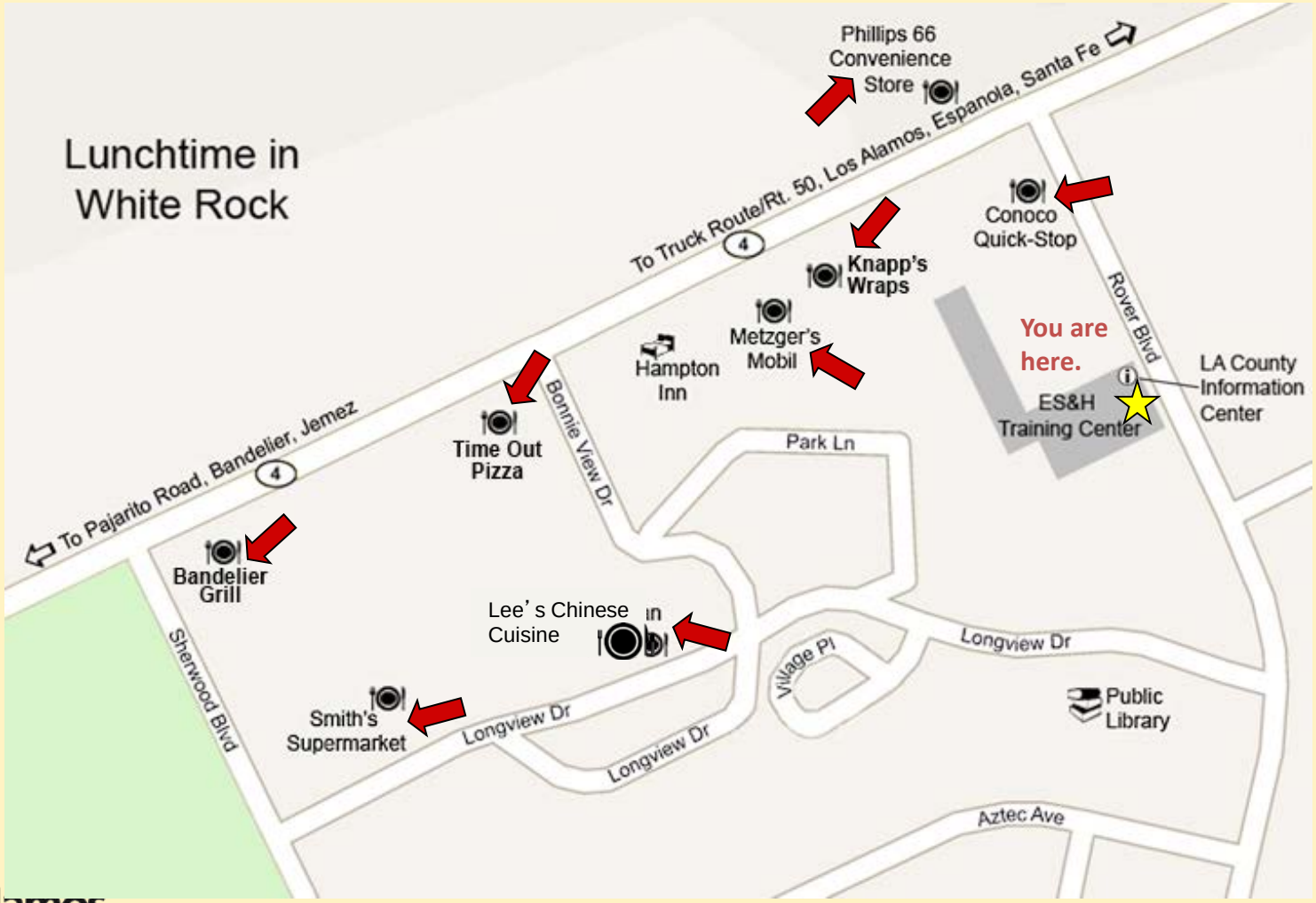
Go to the assembly area when you exit for an emergency.

- DO NOT LEAVE AREA
- NO FOOD OR DRINK
- NO SMOKING
- MINIMIZE TALKING

WRTC Evacuation Assembly Area

After exiting the building during an emergency, assemble at the grassy knoll beside the front parking lot.

Lunchtime in White Rock



You are required to pass an electronic exam with this class.

If you have a CRYPTOCard with administrative (A-level) authorities, you must have it with you to be proctored for the exam.

Basic Radioactive Material Transportation, #30462

This course addresses HMPT training for

- Function-specific training for radioactive material packages containing a single radionuclide

An open-book, multiple-choice test will be given Wednesday at 1:00 p.m.

Course Objectives

After completing this course, you will be able to

- Recognize and use standard international and US customary units to describe activities and exposure rates associated with radioactive material
- Determine whether a quantity of a single radionuclide meets the definition of a class 7 (radioactive) material
- Determine, for a given single radionuclide, the shipping quantity activity limits per 49 Code of Federal Regulations (CFR) 173.435
- Determine the appropriate radioactive material hazard class proper shipping name for a given material

Course Objectives

- Determine when a single radionuclide meets the DOT definition of a hazardous substance
- Determine the appropriate packaging required for a given radioactive material
- Identify the markings to be placed on a package of radioactive material
- Determine the label(s) to apply to a given radioactive material package
- Identify the entry requirements for radioactive material labels

Course Objectives

- Determine the proper placement for radioactive material label(s)
- Identify the shipping paper entry requirements for radioactive material
- Select the appropriate placards for a given radioactive material shipment or vehicle load
- Identify allowable transport limits and unacceptable transport conditions for radioactive material

Target Audience

HMPT training is required for each HAZMAT employee who

- Prepares hazardous materials for shipment
- Loads, unloads, or handles hazardous materials
- Operates a vehicle used to transport hazardous materials
- Is responsible for the safety of transporting hazardous materials

DOT Training Requirements

This type of training . . .	for this type of worker . . .	is provided in . . .
general awareness/ familiarization and safety	all HAZMAT employees	HMPT: Introduction (27916)
function specific	HAZMAT handlers, packagers, and shippers of nonradioactive material	HMPT: Identification of Hazardous Materials (27918), HMPT: Preparing Shipments (27920), and HMPT: Movement by Highway (27922)
	HAZMAT handlers, packagers, and shippers of hazardous waste	HMPT: Hazardous Waste Transportation (27928)
	HAZMAT handlers, packagers, and shippers of class 7 radioactive material	HMPT: Basic Radioactive Material Transportation (30462) and HMPT: Advanced Radioactive Material Transportation (30464)

Course Limitations

- Nonbulk packaging
- Only single, known radionuclides – no mixtures
- No low-specific-activity or surface-contaminated objects
- Transportation of hazardous wastes and explosives covered in other courses
- HAZMAT employers ensure that HAZMAT employee receives required training
- HAZMAT employee keeps supervisor and managers aware of current training

Course Information

Course prerequisites

- HMPT: Introduction (Suggested LIVE 27916, Required TEST 27917)
- HMPT: Identification (Suggested LIVE 27918, Suggested TEST 27919)
- HMPT: Preparing Shipments (Suggested LIVE 27920, Suggested TEST 27921)
- HMPT: Movement by Highway (Suggested LIVE 27922, Suggested TEST 27923)

About this course

- Attend class and sign roster daily for credit for #30462
- Score 80% or better on test to receive credit for #30463

DOT Training Requirements

- 49 CFR 172.704—Six areas of training
- General awareness/familiarization
- **Function specific**
- Safety
- Security awareness
- In-depth security
- Driver (49 CFR 177.816)

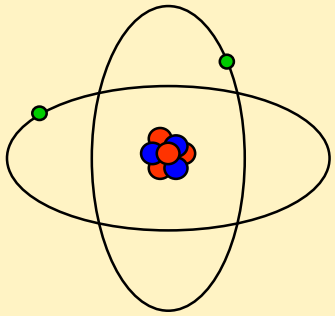
DOT Training Requirements

- New HAZMAT employees must complete initial training within 90 days
- Recurrent (refresher) training must be completed within every 3 years
- Examination in each course to document successful completion of training
- Training must be certified (documented)

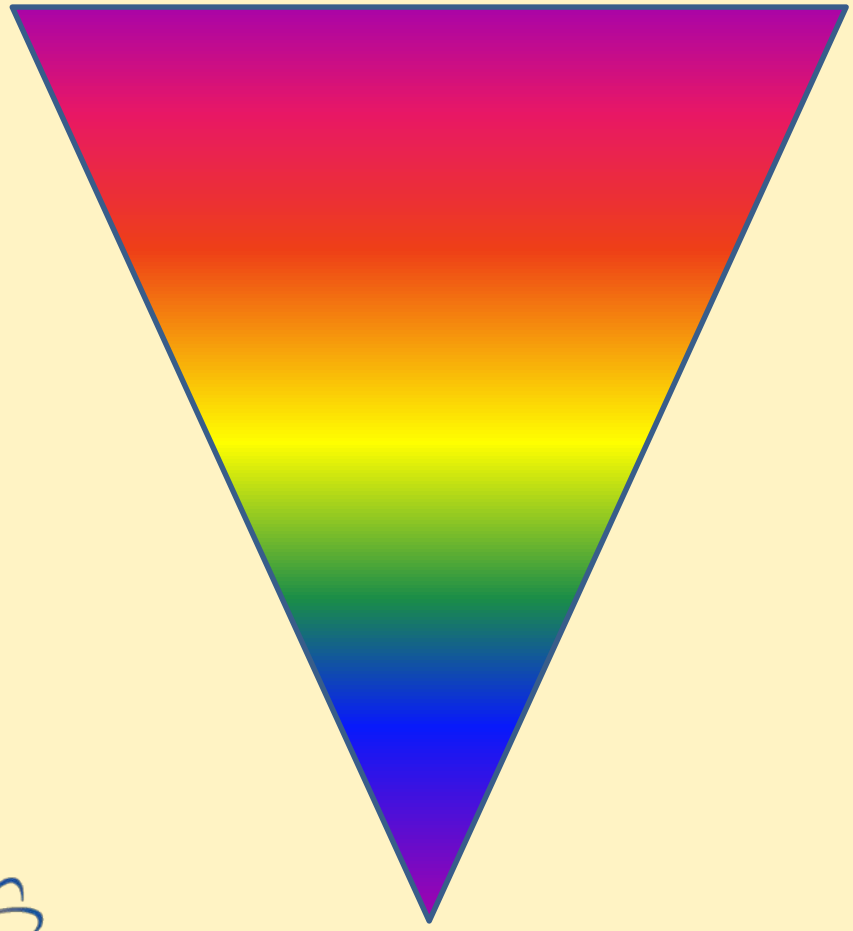
Basic Radioactive Material Transportation #30462

This course provides instruction on the following categories of radioactive material:

- Highway-Route-Controlled Quantities (HRCQs)
- Type-B Quantities
- Type-A Quantities
- Limited Quantities
- Reportable Quantities (RQs)



The Radioactive Material Transportation Scale



- HRCQ
- Type B
- Type A
- Limited Quantities
- Excepted Quantities
- Exempt Quantities

Basic Radioactive Material Transport #30462—cont.

- This course also provides instruction on the requirements for the transport of class 7 (radioactive) material related to
- Determination of class 7 material,
- Packaging,
- Marking,
- Labeling,
- Shipping papers, and
- Placarding

Overview of Class 7 (Radioactive) Material

- Regulation of Radioactive Material Transportation is governed by three federal agencies -
  - DOT
  - NRC
  - DOE

The DOE's policy is to comply fully with DOT hazardous material regulations whenever transporting radioactive materials offsite and, in most cases, during onsite transportation, as well.

DOT Hazard Classes

- Subpart I of Part 173
  - Definitions (49 CFR 173.403)
  - Packaging descriptions and design requirements
  - Criteria for class 7 (radioactive) material
- Subparts C through F of Part 172
  - Marking requirements
  - Labeling requirements
  - Placarding requirements
  - Shipping paper requirements

Ionizing Radiation . . .

. . . a Unique Hazard of Radioactive Material

The **ALARA** principle

- Time
- Distance
- Shielding

Exposure readings may have to be taken.
Removable contamination may have to be measured.

Units of Measure for Radioactive Material

Section Objective

Recognize and use standard international and US customary units to describe activities and exposure rates associated with radioactive material.

SI Units of Measure

Systeme Internationale, or International System of Units (SI) -

- Used in 49 CFR 171-180
  - US standard or customary units appear in parentheses following SI units

- Activity in package of class 7 (radioactive) material must be described primarily in terms of SI units for both domestic and international shipments

SI Units of Measure

Quantity	Unit of Measure	Abbreviation
Volume	liter	L
Mass	gram	g
Time	second	sec
Length	meter	m
Activity in radioactive material	**bequerel**	**Bq**
Ionizing radiation dose equivalent	**sievert**	**Sv**

HMPT_Basic-1_30462_VG,R1.1

SI Units Prefixes

Activity	Prefix	Symbol	Value	Exponent
PBq	peta	P	1,000,000,000,000,000	10^{15}
TBq	tera	T	1,000,000,000,000	10^{12}
GBq	giga	G	1,000,000,000	10^{9}
MBq	mega	M	1,000,000	10^{6}
kBq	kilo	k	1,000	10^{3}
Bq		None	1	$10^{0} = 1$
mBq	milli	m	0.001	10^{-3}
µBq	micro	µ	0.000,001	10^{-6}
nBq	nano	η	0.000,000,001	10^{-9}
pBq	pico	ρ	0.000,000,000,001	10^{-12}

Conversion between SI Standard Units

$$1\,Kg = 1\,Kg\left[\frac{1000\,g}{1\,Kg}\right] = 1,000\,g$$

$$1,000\,g = 1,000\,g\left[\frac{1000\,mg}{1\,g}\right] = 1,000,000\,mg$$

$$1\,mg = 1\,mg\left[\frac{g}{1000\,mg}\right] = 0.001\,g$$

$$0.001\,g = 0.001\,g\left[\frac{Kg}{1000\,g}\right] = 0.000\,001\,Kg$$

Conversion between SI Standard Units—cont.

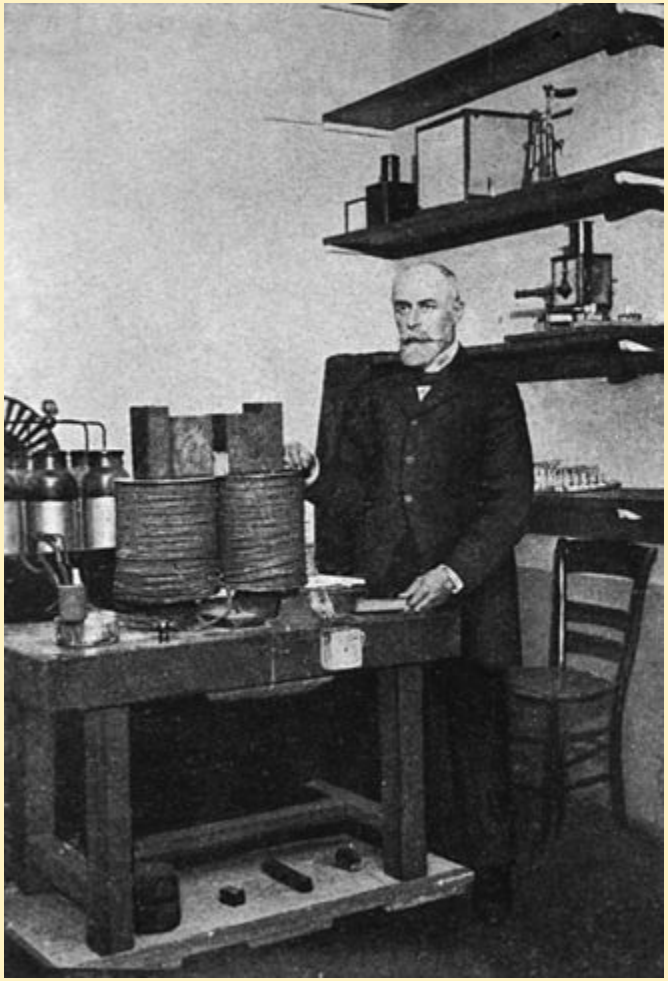
Activity 1

Complete the unit conversion exercise found on page 18 in the Student Manual.

(Answers on page 25)

HMPT_Basic-1_30462_VG,R1.1

Units of Activity



1 **becquerel** of activity = 1 disintegration per second

1 **curie** of activity = 37 billion disintegrations per second

Conversion between US Customary & SI Units of Activity

1 **curie** = 37 billion becquerels

1 **terabecquerel** = 1 trillion becquerels

1 **terabecquerel** = 27 curies

Conversion between US Customary & SI Units of Activity

Unit	Abbreviation	Decays per second
petabequerel	PBq	1,000,000,000,000,000
terabecquerel	TBq	1,000,000,000,000
gigabecquerel	GBq	1,000,000,000
megabecquerel	MBq	1,000,000
kilobecquerel	kBq	1,000
becquerel	Bq	1
curie	Ci	37,000,000,000
millicurie	mCi	37,000,000
microcurie	μCi	37,000

Conversion Equations

(#) Ci x 0.037 TBq/Ci = (#) Tbq

or

(#) Ci ÷ 27 TBq/Ci = (#) Tbq

Activity 2

Complete the unit conversion exercise found on page 20 in the Student Manual.

(Answers on page 25)

Units of Measure for Radiation Exposure

- US customary unit = roentgen equivalent man (rem)
- Per HM-169A, DOT adopted “sievert (Sv)”
- 1 Sv = 100 rem

(#) rem ÷ 100 rem/Sv = (#) Sv
or
(#) rem x 0.01 Sv/rem = (#) Sv

Activity 3

Complete the unit conversion exercise found on page 22 in the Student Manual.

(Answers on page 25)

Self-Assessment—Units of Measure for Radioactive Material

Perform Self-Assessment found in Student Manual

(on page 23)

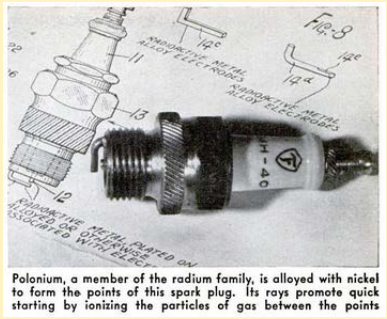
Definition of Class 7 Radioactive Material

Section Objective

Determine whether a quantity of a single radionuclide meets the definition of class 7 (radioactive) material.

What Is Not Class 7?

- If it is not being transported, it is not class 7
- If the radioactive material is in a living being
  - Person or pet with radioactive drug
- Radioactive material built into the vehicle
- Natural material containing natural nuclides
- Nonradioactive solid objects with surface contamination below 173.403 limits



Polonium, a member of the radium family, is alloyed with nickel to form the points of this spark plug. Its rays promote quick starting by ionizing the particles of gas between the points

Definition of Class 7 Radioactive Material—cont.

Class 7 (radioactive) material (according to the DOT) has the same meaning as radioactive material.

Radioactive material is any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table in 49 CFR 173.436 or the values derived according to the instructions in 49 CFR 174.433.

Photo by U.S. N.R.C.

Activity Concentration Limit for Exempt Materials

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

If the specific activity is equal to or less than the radionuclide specific activity (Bq per gram) per 49 CFR 173.436, the material does not meet the definition of class 7 (radioactive) material.

$$\frac{Bq}{g}$$

Therefore, the material is exempt from 49 CFR class 7 DOT hazardous material regulations.

49 CFR 173.436

§173.436 Exempt material activity concentrations and exempt consignment activity limits for radionuclides.

The Table of Exempt material activity concentrations and exempt consignment activity limits for radionuclides is as follows:

Symbol of radionuclide	Element and atomic number	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Ac-225	Actinium (89)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ac-227		1.0×10^{-1}	2.7×10^{-12}	1.0×10^{3}	2.7×10^{-8}
Ac-228		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-105	Silver (47)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ag-108m (b)		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-110m		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-111		1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Al-26	Aluminum (13)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Am-241	Americium (95)	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}

49 CFR 173.436

§173.436 Exempt material activity concentrations and exempt consignment activity limits for radionuclides.

The Table of Exempt material activity concentrations and exempt consignment activity limits for radionuclides is as follows:

Symbol of radionuclide	Element and atomic number	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Ac-225	Actinium (89)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ac-227		1.0×10^{-1}	2.7×10^{-12}	1.0×10^{3}	2.7×10^{-8}
Ac-228		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-105	Silver (47)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ag-108m (b)		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-110m		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-111		1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Al-26	Aluminum (13)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Am-241	Americium (95)	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}

Activity Concentration Limit for Exempt Material

Activity 4

Complete the Determination of Activity Concentration Exempt Values exercise found on page 30 in the Student Manual.

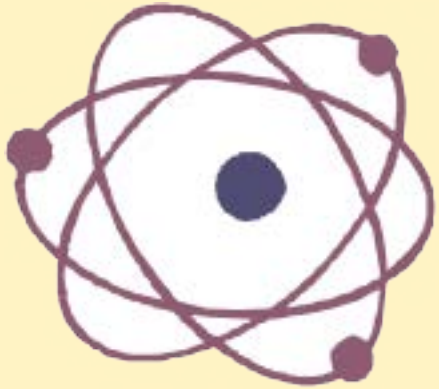
(Answers on page 36)

Activity Limit for Exempt Consignment

Consignment—A package or group of packages or a load of radioactive material offered by a person for transport in the same shipment.

If the consignment radioactive material activity is equal to or less than the radionuclide activity concentration for exempt consignment (Bq) per 49 CFR173.436, the material does not meet the definition of Class 7 (radioactive) material.

Therefore, the material is exempt from 49 CFR class 7 DOT hazardous materials regulations.



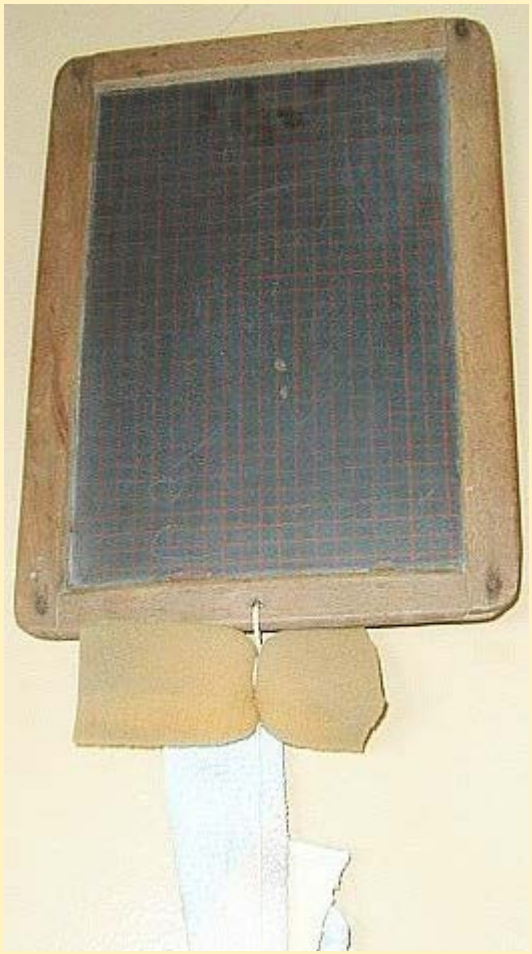
49 CFR 173.436

§173.436 Exempt material activity concentrations and exempt consignment activity limits for radionuclides.

The Table of Exempt material activity concentrations and exempt consignment activity limits for radionuclides is as follows:

Symbol of radionuclide	Element and atomic number	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Ac-225	Actinium (89)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ac-227		1.0×10^{-1}	2.7×10^{-12}	1.0×10^{3}	2.7×10^{-8}
Ac-228		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-105	Silver (47)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ag-108m (b)		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-110m		1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-111		1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Al-26	Aluminum (13)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Am-241	Americium (95)	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}

Activity Limit for Exempt Consignment



Activity 5

Complete the Determination of Activity Concentration Exempt Values exercise found on page 33 in the Student Manual.

(Answers on page 36)

DOT-Regulated Class 7 (Radioactive) Material

Activity 6

Complete the Determination of DOT-regulated Class 7 (radioactive) materials exercise found on page 34 in the Student Manual.

(Answers on page 36)

Self-Assessment—Definition of Class 7 Radioactive Material

Perform Self-Assessment found in Student Manual

(on page 35)

Shipping Quantities for Radioactive Material

Section Objective

Determine, for a given single radionuclide, the shipping quantity activity limits per 49 CFR 173.435

Shipping Quantities for Radioactive Materials—cont.

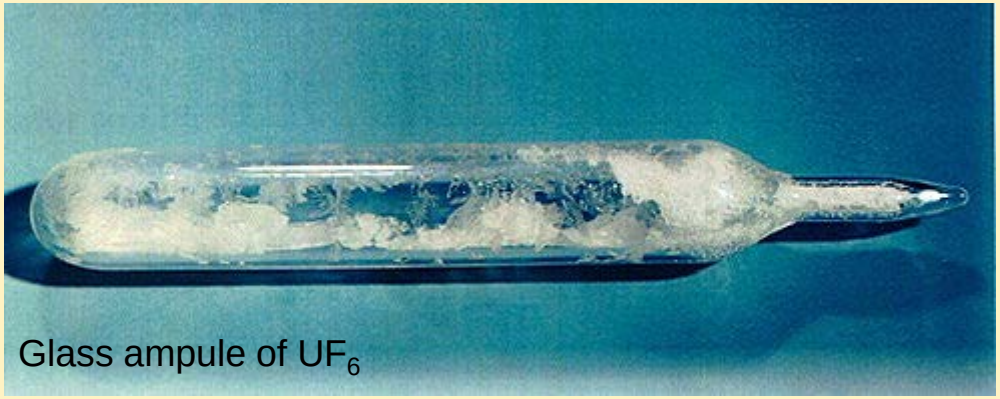
Special-form, class 7 (radioactive) material

- Either a single solid piece or material contained in a sealed capsule that can be opened only by destroying the capsule;
- the piece or capsule has a least one dimension not less than 5 mm (0.2 in.), and
- it satisfies the test requirements of 49 CFR 173.469 (with some exceptions).

Shipping Quantities for Radioactive Material—cont.

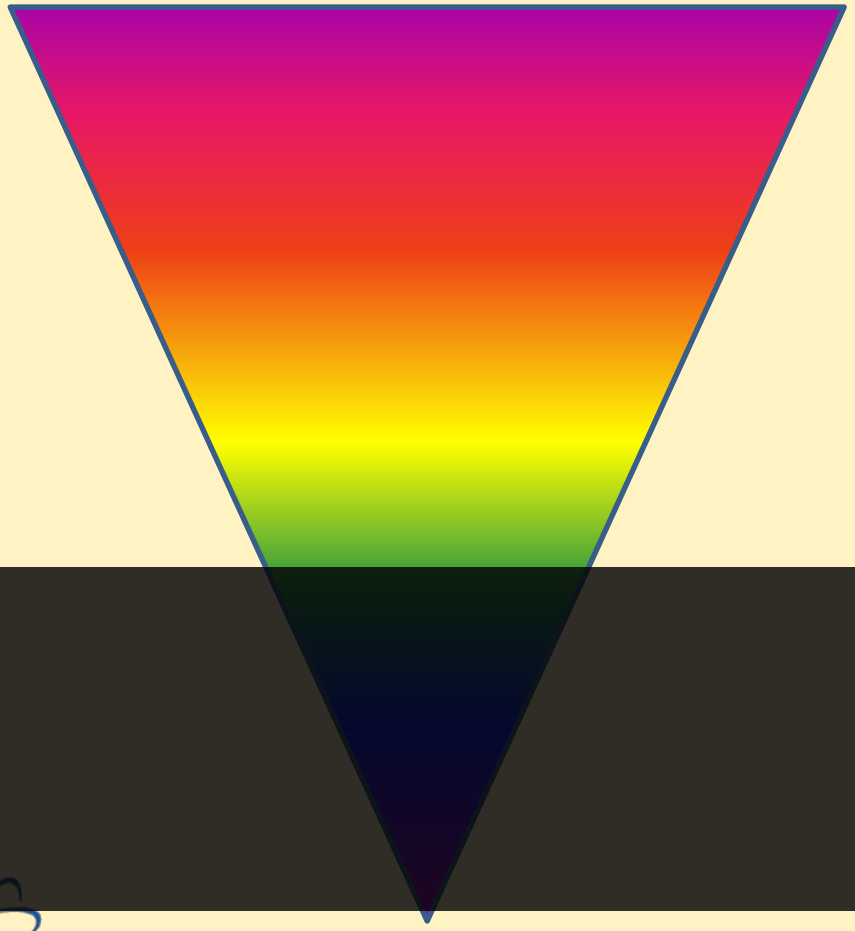
Normal-form, class 7 (radioactive) material

- If a class 7 (radioactive) material is not in special form, then it is in normal (other) form.



Glass ampule of UF_6

Shipping Quantities for Radioactive Material—cont.



- HRCQ
- Type B
- Type A
- Limited Quantities
- Excepted Quantities
- Exempt Quantities

Shipping Quantities for Radioactive Materials—A Aalues

A_1 - the maximum activity of special-form, class 7 (radioactive) material permitted in a Type-A package.

A_2 - the maximum activity of class 7 (radioactive) material, other than special form, LSA, or SCO, permitted in a Type-A package. (LSA and SCO will be defined later in this course.)

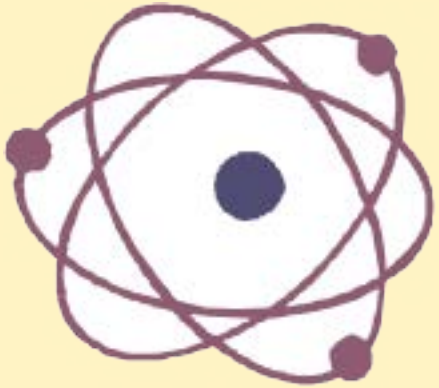
Shipping Quantities for Radioactive Material—cont.

Determination of Values for A_1 and A_2

Table of A_1 and A_2 Values for Radionuclides

49 CFR 173.435

Columns 1 - 8



49 CFR 173.435

Symbol of radionuclide	Element and atomic number	A_1 (TBq)	A_1 (Ci)[b]	A_2 (TBq)	A_2 (Ci)[b]	Specific activity	
						(TBq/g)	(Ci/g)
Ac-225 (a)	Actinium (89)	8.0×10^{-1}	2.2×10^{1}	6.0×10^{-3}	1.6×10^{-1}	2.1×10^{3}	5.8×10^{4}
Ac-227 (a)		9.0×10^{-1}	2.4×10^{1}	9.0×10^{-5}	2.4×10^{-3}	2.7	7.2×10^{1}
Ac-228		6.0×10^{-1}	1.6×10^{1}	5.0×10^{-1}	1.4×10^{1}	8.4×10^{4}	2.2×10^{6}
Ag-105	Silver (47)	2.0	5.4×10^{1}	2.0	5.4×10^{1}	1.1×10^{3}	3.0×10^{4}
Ag-108m (a)		7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}	9.7×10^{-1}	2.6×10^{1}
Ag-110m (a)		4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}	1.8×10^{2}	4.7×10^{3}
Ag-111		2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}	5.8×10^{3}	1.6×10^{5}
Al-26	Aluminum (13)	1.0×10^{-1}	2.7	1.0×10^{-1}	2.7	7.0×10^{-4}	1.9×10^{-2}
Am-241	Americium (95)	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}	1.3×10^{-1}	3.4

Shipping Quantities Radioactive Material—cont.

Determination of Values for A_1 and A_2

Activity 7

Complete the Determination of Values for
A_1 and A_2 exercise found on page 43 in the Student Manual.
(Answers on page 57)

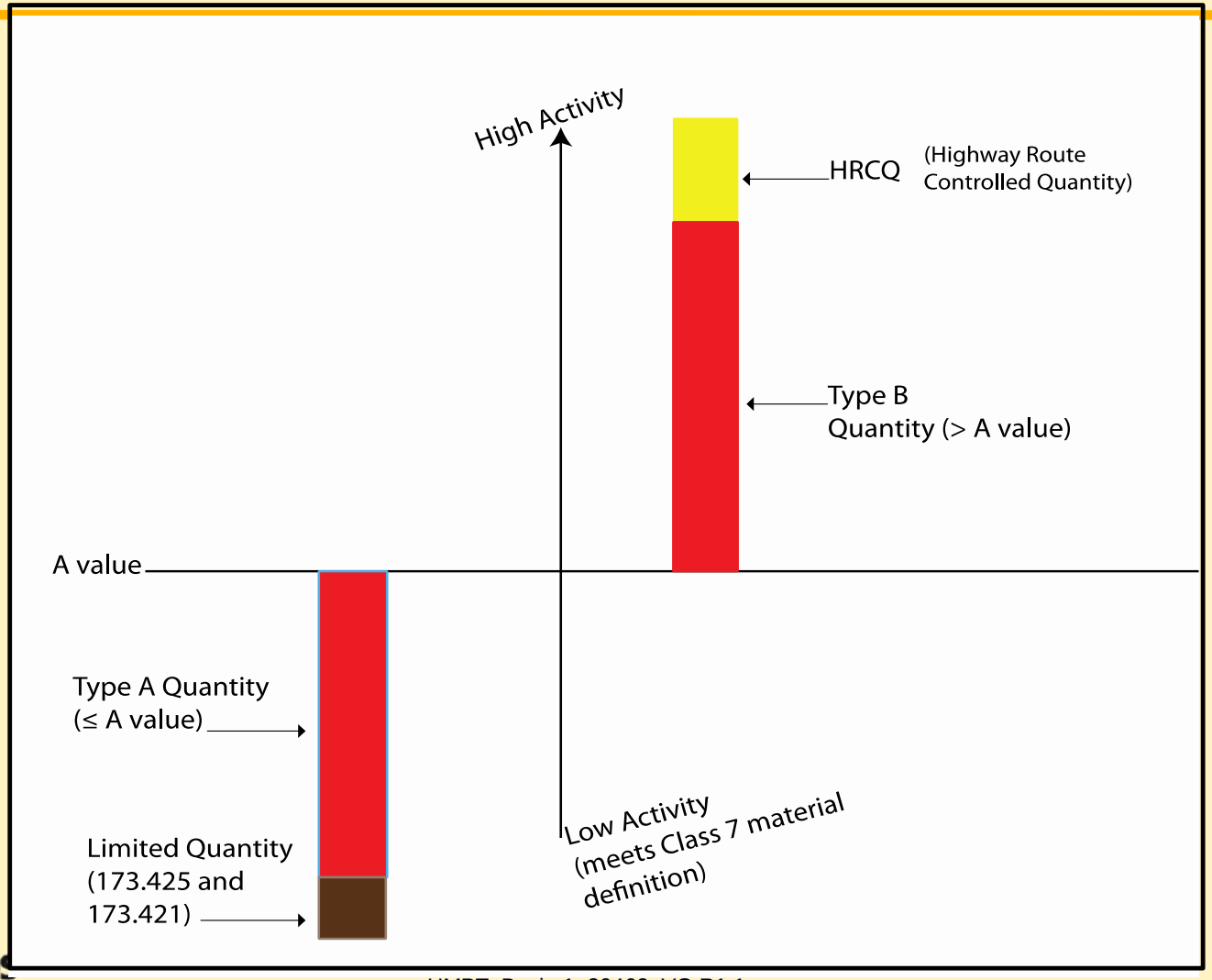
Shipping Quantities for Radioactive Material—cont.

Determination of Type-A and Type-B Quantities

Type-A quantity - a quantity of class 7 (radioactive) material, the aggregate radioactivity of which does not exceed (≤) **A_1 for special-form** class 7 (radioactive) material or **A_2 for normal-form** class 7 (radioactive) material.

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

Radioactive Material Shipping Categories



Shipping Categories for Radioactive Material—cont.

Determination of Type-A and Type-B Quantities

Activity 8

Complete the Determination of Type-A and Type-B Quantities exercise found on page 44 in the Student Manual.

(Answers on page 57)

Shipping Categories for Radioactive Material—cont.

Highway-Route-Controlled Quantities

- Exceeds 3000 times the A_1 value of the radionuclide as specified in 49 CFR 173.435 for special form;
- Exceeds 3000 times the A_2 value of the radionuclide as specified in 49 CFR 173.435 for normal form; or
- Exceeds 1000 TBq (27,000 Ci), whichever is least.

HMPT_Basic-1_30462_VG,R1.1

Shipping Categories for Radioactive Material—cont.

Determination of HRCQs

Activity 9

Complete the Determination of HRCQs exercise found on page 46 in the Student Manual.

(Answers on page 58)

Shipping Categories for Radioactive Material—cont.

Limited Quantities of Radioactive Material

A Limited Quantity of class 7 (radioactive) material cannot exceed the material's package limit specified in 173.425 and conforming with requirements specified in 173.421 (and 173.422).

HMPT_Basic-1_30462_VG,R1.1

Shipping Categories for Radioactive Material—cont.

Limited Quantities of Radioactive Material

173.425— Table of activity limits—excepted quantities and articles; see next slide

173.421— Excepted packages for limited quantities of class 7 material

173.422— Additional requirements for excepted packages containing class 7 material

49 CFR 173.425

TABLE 4—ACTIVITY LIMITS FOR LIMITED QUANTITIES, INSTRUMENTS, AND ARTICLES

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

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

Limited Quantities of Radioactive Material

Activity limits for limited quantities based on the following characteristics of the radioactive material:

- the DOT shipping form (special or other)
- the physical form of the material (solid, liquid, or gas)
- the radionuclide (tritium or other)

Shipping Categories for Radioactive Material—cont.

Limited Quantities of Radioactive Material

Maximum activity for a limited quantity of a gas or a solid - A_x = appropriate "A" value.

(A_x) x (0.001) = maximum activity for a limited quantity
or (because both of these calculations give the same result)
(A_x) ÷ (1000) = maximum activity for a limited quantity

Shipping Categories for Radioactive Material—cont.

Limited Quantities of Radioactive Material

Maximum activity for a limited quantity of a liquid -
A_x = appropriate "A" value.

(A_x) x (0.0001) = maximum activity for a limited quantity
or
(A_x) ÷ (10,000) = maximum activity for a limited quantity

Shipping Categories for Radioactive Material—cont.

Determination of Limited Quantities

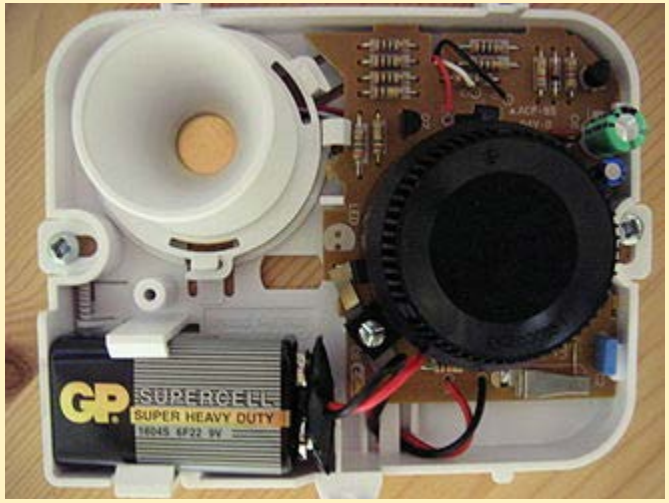
Activity 10

Complete the Determination of Limited Quantities exercise found on page 50 in the Student Manual.

(Answers on page 58)

Shipping Categories for Radioactive Material—cont.

Activity Limits for Radioactive Instruments or Articles



49 CFR 173.425

TABLE 4—ACTIVITY LIMITS FOR LIMITED QUANTITIES, INSTRUMENTS, AND ARTICLES

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

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

Self-Assessment—Shipping Categories for Radioactive Material

Perform Self-Assessment

For Shipping Categories Found

In Student Manual

(on pages 54/55)

You are required to pass an electronic exam with this class.

If you have a CRYPTOCard with administrative (A-level) authorities, you must have it with you to be proctored for the exam.

Hazardous Material Packaging and Transportation

Department of Energy National Transportation Program

LANL #30462 - Basic Radioactive Material Transportation

January 2016 – Part 2

Proper Shipping Names for Radioactive Material

Section Objective

Determine the proper shipping name of the appropriate radioactive material hazard class for a given material.

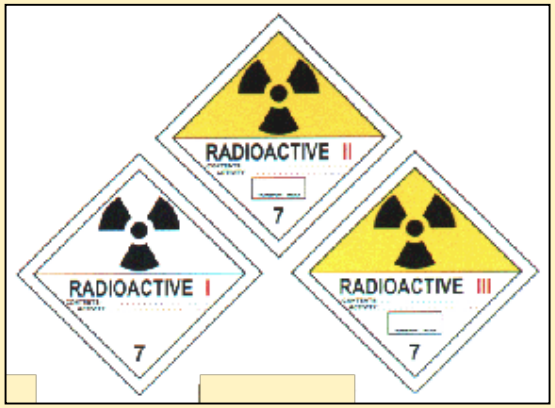
Proper Shipping Names for Radioactive Material—cont.

For . . .	the PSNs that apply are . . .	UN
uranium hexafluoride	• **Radioactive material, uranium hexafluoride, fissile**; and	UN2977
	• **Radioactive material, uranium hexafluoride,** nonfissile or fissile excepted.	UN2978
	• **Uranium hexafluoride, radioactive material, excepted package**, <0.1 kg per package, nonfissile or fissile-excepted.	UN3507
special arrangements	• **Radioactive material, transported under special arrangement fissile**; and	UN3331
	• **Radioactive material, transported under special arrangement,** nonfissile or fissile excepted.	UN2919
fissile	• **Radioactive material, uranium hexafluoride, fissile;**	UN2977
	• **Radioactive material, transported under special arrangement, fissile;**	UN3331
	• **Radioactive material, Type-B(M) package, fissile;**	UN3329
	• **Radioactive material Type-B(U) package, fissile;**	UN3328
	• **Radioactive material, Type-A package, special-form fissile**; and	UN3333
	• **Radioactive material, Type-A package fissile,** nonspecial form.	UN3327
Type-B packages Note: Type-B ( ) packages are to use the applicable Type-B (U) PSN	• **Radioactive material, Type-B(M) package, fissile;**	UN3329
	• **Radioactive material, Type-B(M) package** nonfissile or fissile excepted;	UN2917
	• **Radioactive material, Type-B(U) package, fissile; and**	UN3328
	• **Radioactive material, Type-B(U) package** nonfissile or fissile excepted.	UN2916

Proper Shipping Names for Radioactive Material—cont.

For . . .	the PSNs that apply are . . .	UN
special form	• **Radioactive material, Type-A package, special form, fissile;** • **Radioactive material, Type-A package, special form,** *nonfissile or fissile excepted.*	**UN3333** **UN3332**
type-A packages	• **Radioactive material, Type-A package, special form, fissile;** • **Radioactive material, Type-A package, special form,** *nonfissile or fissile excepted;* • **Radioactive material, Type-A package, fissile,** *nonspecial form*; and • **Radioactive material, Type-A package,** *nonspecial form, nonfissile or fissile excepted.*	**UN3333** **UN3332** **UN3327** **UN2915**
excepted packages	• **Radioactive material, excepted package—empty package;** • **Radioactive material, excepted package—limited quantity of material;** • **Radioactive material, excepted package—instruments or articles;** and • **Radioactive material, excepted package—articles manufactured from natural uranium** *or* **depleted uranium** *or* **natural thorium**.	**UN2908** **UN2910** **UN2911** **UN2909**
low specific activity	• **Radioactive material, low specific activity (LSA-I),** *nonfissile or fissile excepted;* • **Radioactive material, low specific activity (LSA-II),** *nonfissile or fissile excepted;* and • **Radioactive material, low specific activity (LSA-III)** *nonfissile or fissile excepted.*	**UN2912** **UN3321** **UN3322**
surface-contaminated objects	• **Radioactive material, surface-contaminated objects (SCO-I** or **SCO-II),** *nonfissile or fissile excepted.*	**UN2913**

Proper Shipping Names for Radioactive Material—cont.

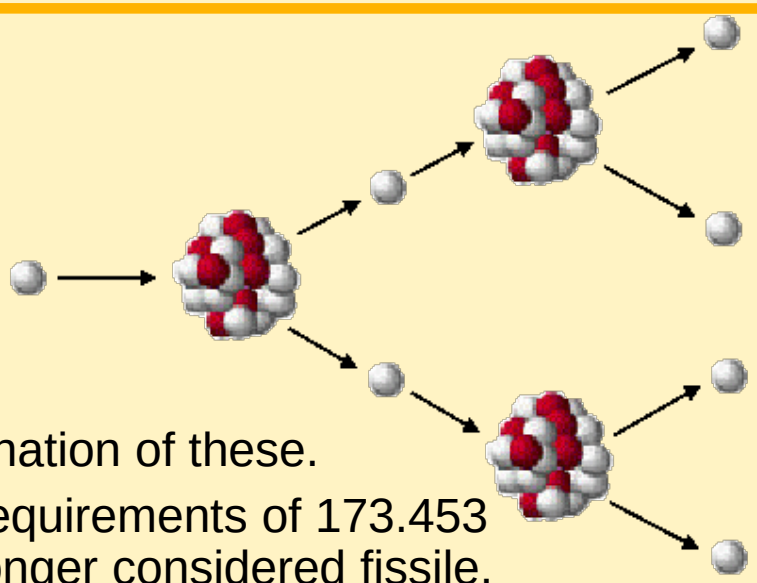


- PSNs for **fissile** material contain the word "fissile"; nonfissile or fissile-excepted PSNs are identified by the words *"non-fissile or fissile excepted"* in italics.
- PSNs applicable to **special-form** material contain the words "special form"; nonspecial-form material PSNs are identified by the words *"nonspecial form"* in italics.
- Italicized words are not marked on the package and are not listed on the shipping paper.

Proper Shipping Names for Radioactive Material—cont.

- Packaging specifically for **Type A, Type B(M), and Type B(U)** are now identified in each PSN.
- **Special Arrangement** - provisions approved by the competent authority, under which consignments that do not satisfy all the applicable requirements, may be transported.

Proper Shipping Names for Radioactive Material—cont.



Uranium Hexafluoride

- Regulated by NRC and DOT

Fissile Material

- ^{239}Pu, ^{241}Pu, ^{233}U, ^{235}U, or any combination of these.
- Excepted (not exempt) if they meet requirements of 173.453 paragraphs a through f. Material is no longer considered fissile, and a PSN containing the word “fissile” is not used.
- Additional layers of regulations designed to preclude criticality accidents.
- Criticality Safety Index is a value provided in the package paperwork.
- Each package or overpack containing fissile material, other than fissile-excepted material, must bear two FISSILE labels.

Proper Shipping Names for Radioactive Materials—cont.

Special-Arrangement PSNs

- **"Radioactive material, transported under special arrangement, fissile"**
- **"Radioactive material, transported under special arrangement,** nonfissile, or fissile excepted"

Proper Shipping Names for Radioactive Material—cont.

Type-B(M) and Type-B(U) Packages

- Used when nonfissile or fissile-excepted radioactive material (having an activity that exceeds a Type-A quantity) is shipped
- "M" identifies multilateral packaging approval
- "U" identifies unilateral packaging approval

Proper Shipping Names for Radioactive Material—cont.

Type-A Packages

- Normal form radioactive material (having an activity that is less than or equal to its A_2 value) to be shipped
- Special-form radioactive material (having an activity that is less than or equal to its A_1 value) to be shipped
- **"Radioactive material, Type A package, special form, fissile"**
- **"Radioactive material, Type A package, special form,** nonfissile or fissile excepted"

Proper Shipping Names for Radioactive Material—cont.

Type-A Packages – Special-Form Material

- Indispersible solid radioactive material or
- Sealed capsule containing radioactive material

Proper Shipping Names for Radioactive Material—cont.

Excepted Package - Empty Package

Package must be emptied of contents as far as practical (ALARA – AFAPra?)

Excepted from

- **Marking** (except for the UN identification number marking requirement described in paragraph 173.422[a])
- **Labeling** (except for the specified “Empty” label)
- **Shipping papers and certification**

Proper Shipping Names for Radioactive Material—cont.

Excepted Package - Limited Quantity of Material

Excepted from

- **Specification packaging**
- **Marking** (except for the UN identification number marking requirement described in paragraph 173.422 [a])
- **Labeling**
- **Shipping papers and certification** (if the material is not a hazardous substance or a hazardous waste)

Proper Shipping Names for Radioactive Material—cont.

Excepted Package - Instruments or Articles

Excepted from

- **Specification packaging**
- **Marking** (outside of each package must be marked with the four-digit UN identification number for the material preceded by the letters “UN” as shown in column 4 of the Hazardous Material Table in 172.101)
- **Labeling**
- **Shipping papers and certification** (if the material is not a hazardous substance or a hazardous waste)

Proper Shipping Names for Radioactive Material—cont.

Excepted Package - Articles Manufactured from Natural *or* Depleted Uranium *or* Natural Thorium

Excepted from

- **Specification packaging**
- **Marking**. The outside of each package must be marked with the four-digit UN identification number for the material, preceded by the letters "UN," as shown in column 4 of the Hazardous Material Table in 172.101
- **Labeling**
- **Shipping papers and certification** (if the material is not a hazardous substance or a hazardous waste).

Proper Shipping Names for Radioactive Material—cont.

Excepted Package - Low Specific Activity (LSA) Material

3 Groups

- LSA-I
- LSA-II
- LSA-III

Proper Shipping Names for Radioactive Material—LSA-I

- Primordial nuclide ores
- Solid unirradiated U/DU/Th
- A_2 unlimited material
- Activity < 30x the 49CFR173.436 limits or 49CFR173.433 limits

Proper Shipping Names for Radioactive Material—LSA-II

- Water with tritium <0.8 TBq/L (20 Ci/L)
- Specific activity $<10^{-4}$ A_2/g for solids, gasses
- Specific activity $<10^{-5}$ A_2/g for liquids

Proper Shipping Names for Radioactive Material—LSA-III

- Solids (no powders)
- Bound, low leaching
- Specific activity <2 x 10^{-3} A_2/g

Proper Shipping Names for Radioactive Material—cont.

Surface-Contaminated Objects
SCO-I

A solid object on which

- the nonfixed contamination on the accessible surface, averaged over 300 cm^2 (or the area of the surface if <300 cm^2), does not exceed 4 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters, or 0.4 Bq/cm^2 for all other alpha emitters;
- the fixed contamination on the accessible surface, averaged over 300 cm^2 (or the area of the surface if <300 cm^2), does not exceed 4 x 10^4 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters, or 4 x 10^3 Bq/cm^2 for all other alpha emitters; and
- the nonfixed contamination, plus the fixed contamination on the inaccessible surface, averaged over 300 cm^2 (or the area of the surface if <300 cm^2), does not exceed 4 x 10^4 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters or 4 x 10^3 Bq/cm^2 for all other alpha emitters.

Additional requirements are stipulated in 49 CFR 173.427.

Proper Shipping Names for Radioactive Material—cont.

Surface Contaminated Objects
SCO-II

A solid object on which the limits for SCO-I are exceeded and on which

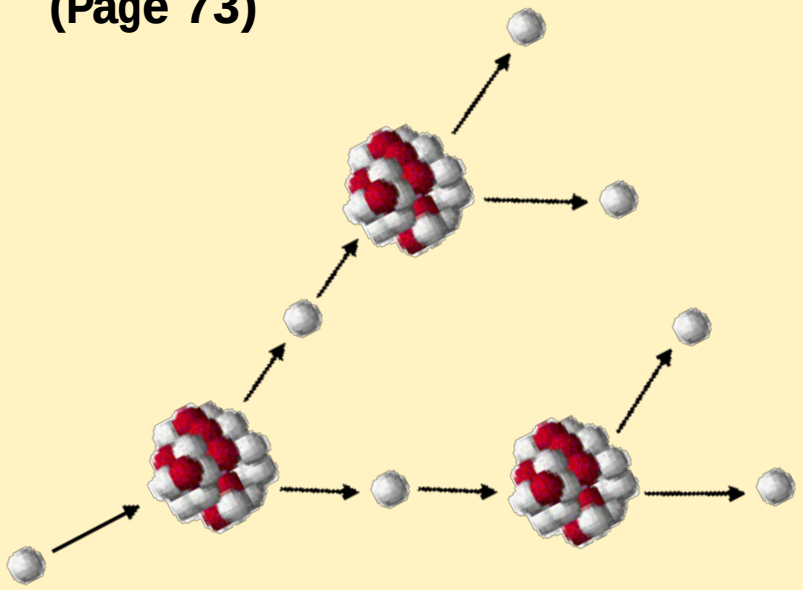
- the nonfixed contamination on the accessible surface, averaged over 300 cm^2 (or the area of the surface if <300 cm^2), does not exceed 400 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters, or 40 Bq/cm^2 for all other alpha emitters;
- the fixed contamination on the accessible surface, averaged over 300 cm^2 (or the area of the surface if <300 cm^2), does not exceed 8×10^5 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters, or 8×10^4 Bq/cm^2 for all other alpha emitters; and
- the nonfixed contamination, plus the fixed contamination on the inaccessible surface, averaged over 300 cm^2 (or the area of the surface if <300 cm^2), does not exceed 8×10^5 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters or 8×10^4 Bq/cm^2 for all other alpha emitters.

Additional requirements are stipulated in 49 CFR 173.427.

Proper Shipping Names for Radioactive Material—cont.

Perform Self-Assessment in Student Manual

(Page 73)



Requirements for Hazardous Substances

Section Objective

Upon completion of this section, determine when a single radionuclide meets the DOT definition of a hazardous substance.

Requirements for Hazardous Substances – cont.

Requirements for Defining a Hazardous Substance

- Listed in Appendix A to 49 CFR 172.101
- In a quantity, in one package, that equals or exceeds the RQ listed in Appendix A to 49 CFR 172.101
- It is a radionuclide in a mixture or solution, conforms to paragraph 7 of Appendix A of 49 CFR 172.101

Requirements for Hazardous Substances – cont.

Determination of RQ Values for Single, Known Radionuclides

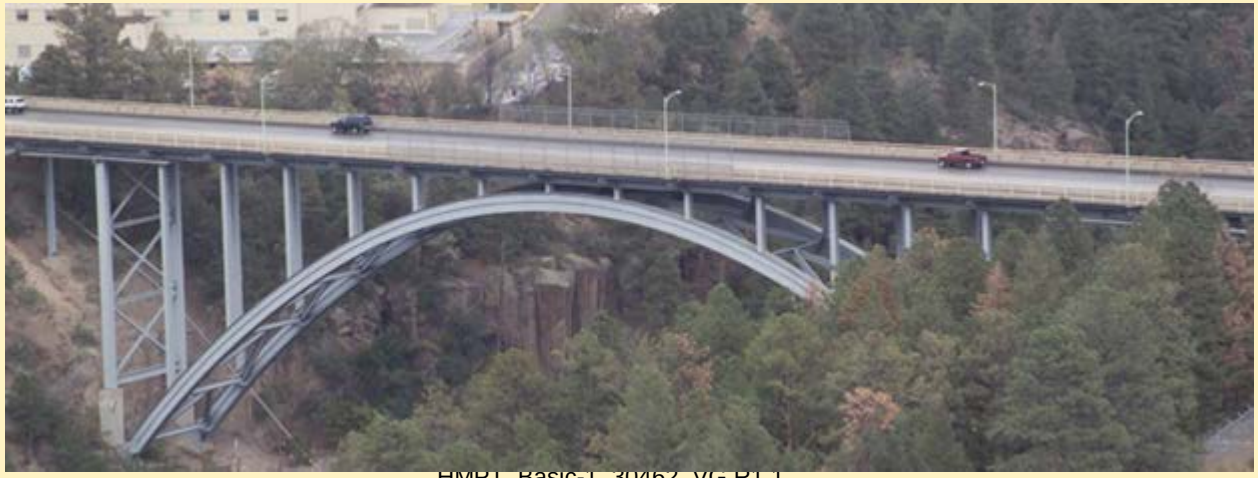
- If a radionuclide is not listed in Table 2, it is automatically assigned an RQ value of 0.037 TBq (1 Ci).
- Whenever the RQs listed in Table 1 and Table 2 conflict, the lower RQ shall apply.

Requirements for Hazardous Substances – cont.

Activity 11
(page 80)

Determination of RQ Values for Single, Known Radionuclides and

Perform Self-Assessment in Student Manual
(page 81)



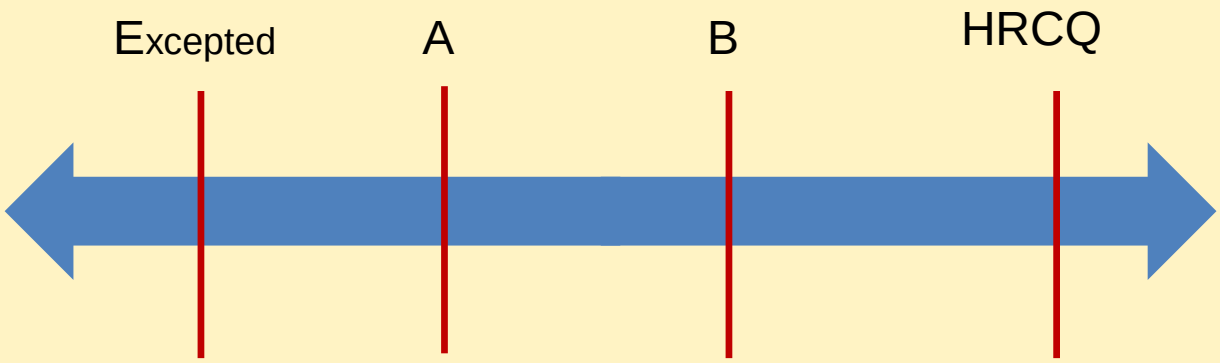
Packaging Requirements for Radioactive Material

Section Objective

Upon completion of this section, you will be able to determine the appropriate packaging required for a given radioactive material.

Packaging Requirements for Radioactive Material—cont.

- Type-B packagings
- Type-A packagings
- Industrial packagings
- Excepted packagings



Packaging Requirements for Radioactive Material—cont.

Excepted Packagings (nonbulk)

- Limited quantities
- Instruments or articles (excepted quantities)
- LSA material (exclusive use only, domestic, total activity less than or equal to Type-A quantity)
- SCOs (exclusive use only, domestic, total activity less than or equal to Type-A quantity)
- Manufactured articles containing only natural or depleted uranium or natural thorium
- Empty packagings

Empty Packagings

§ 173.428 Empty Class 7 (radioactive) materials packaging.

A packaging which previously contained Class 7 (radioactive) materials and has been emptied of contents as far as practical, is excepted from the shipping paper and marking (except for the UN identification number marking requirement described in § 173.422(a)) requirements of this subchapter, provided that—

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

(b) External radiation levels below 0.005 mSv/h (0.5 mrem/h)

(c) Non-fixed contamination ALARA and below table 173.443 table 9 values: beta/gamma 240 dpm/cm^2 alpha 24 dpm/cm^2

(e) Low fissile material content – less than 2g, or less than 15 g fissile for every 200g nonfissile, etc.; see 173.453 for further detail

(b) The packaging is in unimpaired condition and is securely closed so that there will be no leakage…

(c) (Summary) *Radiation shields made of radioactive metal cannot be bare radioactive metal*;

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

(e) (Summary) *Replace previous labels with the 172.450 "Empty" label*

(f) The packaging is prepared for shipment as specified in § 173.422 – *standard excepted packaging requirements*

- Clearly, packagings that still have detectable radioactive material can meet these criteria. Absolutely zero material/contamination is not required/unrealistic.

Packaging Requirements for Radioactive Material—cont.

Type-A Packagings can be used for

- Fissile material
- Fissile material, excepted quantities
- Special-form material
- LSA material (nonexclusive use or greater than Type-A quantities)
- SCOs (nonexclusive use or greater than Type-A quantities)
- Specifically listed radioactive material proper shipping names

Packaging Requirements for Radioactive Material—cont.

Performance Requirement for Type-A Packaging

Evaluated against tests specified by 49 CFR 173.465 (or 49 CFR 173.461)

- Water spray,
- Free drop,
- Stacking, and
- Penetration

Packaging Requirements for Radioactive Material—cont.

Type-B Packagings

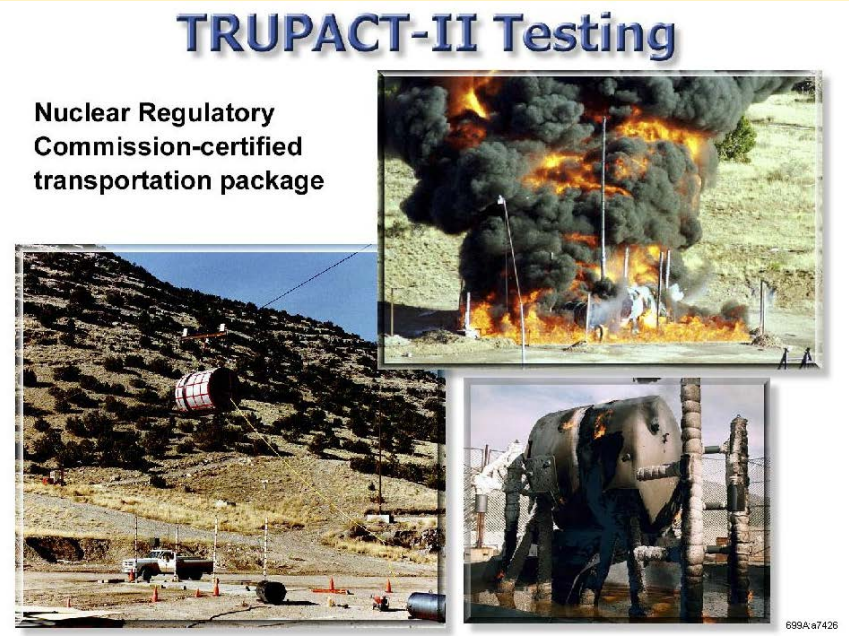
- Fissile material
- Fissile materials, excepted quantities
- Special-form material
- “Specifically listed” radioactive material proper shipping names

Packaging Requirements for Radioactive Material—cont.

Performance Requirements for Type-B Packagings

The following four tests are required:

- Mechanical (drop and crush),
- Puncture,
- Fire, and
- Immersion



http://www.wipp.energy.gov/fctshts/TRUwastecontainers.pdf

Packaging Requirements for Radioactive Material—cont.

Perform Self-Assessment in Student Manual
(Page 96)

Marking Requirements for Radioactive Material

Section Objective

Upon completion of this section, identify the markings to be placed on a package of radioactive material.

Marking Requirements for Radioactive Material—cont.

- General Marking Requirements
- Specific Marking Requirements
- Additional Marking Requirements

Marking Requirements for Radioactive Materials—cont.

Marking Specifications

- Durable, in English, and printed on or affixed to the surface of a package or on a label, or sign
- Displayed on a background of sharply contrasting color
- Unobscured by labels or attachments
- Located away from any other marking that could substantially reduce its effectiveness

Marking Requirements for Radioactive Material—cont.

Exceptions from Marking Requirements

- Limited quantities,
- Instruments and articles,
- Manufactured articles,
- LSA and SCO, and
- Empty radioactive material packaging

Marking Requirements for Radioactive Material—cont.

Perform Self-Assessment in Student Manual (Page 101)

Labeling Requirements for Radioactive Material

Section Objectives

Upon completion of this section, you will

- Determine the label(s) to apply to a given radioactive material package,
- Identify the entry requirements for radioactive material label(s), and
- Determine the proper placement for radioactive material label(s)

General Labeling Requirements

- RADIOACTIVE WHITE-I (49 CFR 172.436),
- RADIOACTIVE YELLOW-II (49 CFR 172.438),
- RADIOACTIVE YELLOW-III (49 CFR 172.440),
- FISSILE (49 CFR 172.441), and
- EMPTY (49 CFR 172.450)

General Labeling Requirements—cont.

Class 7 (Radioactive) Material Labeling Requirements				
TI (at 1 meter)	Surface Dose Rate			
	≤0.5 mrem/h	>0.5 and ≤50 mrem/h	>50 and ≤200 mrem/h	>200 and ≤1000 mrem/h
TI = 0[1]	White - I	Yellow - II	Yellow - III	Yellow - III[2]
TI > 0 and TI ≤ 1	Yellow - II	Yellow - II	Yellow - III	Yellow - III[2]
TI > 1 and TI ≤ 10	Yellow - III	Yellow - III	Yellow - III	Yellow - III[2]
TI > 10	Yellow - III[2]	Yellow - III[2]	Yellow - III[2]	Yellow - III[2]

[1] If the measured TI is not greater than 0.05, the value may be considered to be zero.
[2] Must be shipped under exclusive use provisions [49 CFR 173.441(b)].
Note: Any HRCQ must be labeled RADIOACTIVE YELLOW-III.

General Labeling Requirements—cont.

- Contents (except for LSA-I), 49 CFR 172.403(g)(1),
- Activity in Bq – you can put (Ci) after Bq, and
- TI (RADIOACTIVE YELLOW-II and RADIOACTIVE YELLOW-III labels only)

General Labeling Requirements—cont.

Entry Requirements for Radioactive Waste				
Label	**Content**	**Activity**	**TI**	**CSI**
RADIOACTIVE WHITE-I	x	x	_	_
RADIOACTIVE YELLOW-II	x	x	x	_
RADIOACTIVE YELLOW-III	x	x	x	_
FISSILE	_	_	_	x

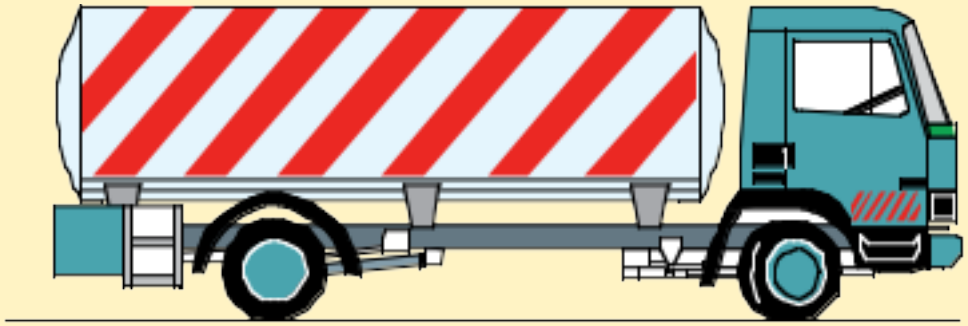
Additional Labeling Requirements

- Label Placement
- Labeling for Secondary Hazards
- Label Specifications
- Empty Labels
- Fissile Labels

Labeling Requirements for Radioactive Materials

Perform Self-Assessment in Student Manual

(Page 109)



Shipping Paper Requirements for Radioactive Material

Section Objective

Upon completion of this section, you will be able to identify shipping paper entry requirements for radioactive material.

Shipping Paper Requirements for Radioactive Material—cont.

General Shipping Requirements

- Hazardous material entries must be clearly identified,
- Descriptions must be legible and printed in English,
- Descriptions may not contain any code or abbreviation unless specifically authorized by 49 CFR 171–180, and
- A shipping paper must contain an emergency response telephone number as prescribed in 49 CFR 172, Subpart G

Shipping Paper Requirements for Radioactive Material—cont.

Hazardous Material Description

- Identification number,
- Proper shipping name,
- Hazard class,
- Packing group (not required for class 7 [radioactive] materials),
- Quantity, and
- Package type and count

Shipping Paper Requirements for Radioactive Material—cont.

Additional Description Requirements

- DOT exemptions,
- Limited quantities (if shipping paper is required),
- Hazardous substances, and
- Class 7 (radioactive) material

Shipping Paper Requirements for Radioactive Materials—cont.

Shipper's Certification

Unless excepted, a shipping paper must also contain –

- A certification statement (verbatim from CFR)*
- A signature

* "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." OR

"I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations."

Shipping Paper Requirements for Radioactive Material—cont.

Perform Self-Assessment in Student Manual

(Page 117)

Placarding Requirements for Radioactive Material

Section Objective

Upon completion of this section,
you will be able to select the appropriate placards for a given radioactive material shipment or vehicle load.

Placarding Requirements for Radioactive Material—cont.

General Placarding Requirements

- Packages displaying a RADIOACTIVE YELLOW- III label,
- LSA material shipped domestically as exclusive use, or
- SCO shipped domestically as exclusive use

Placarding Requirements for Radioactive Material—cont.

Placard Location and Configuration

- The shipper is responsible for supplying the placards for the material being offered to the carrier
- The shipper is not responsible for materials that are already loaded on the transport vehicle
- The carrier is responsible for affixing the placards and for making certain the vehicle is properly placarded to communicate all the hazards aboard

Placarding Requirements for Radioactive Material—cont.

Specific Placarding Requirements

Placarding Requirements for Radioactive Material—cont.

Perform Self-Assessment in Student Manual

(Page 121)

Additional Transportation Requirements and Limitations

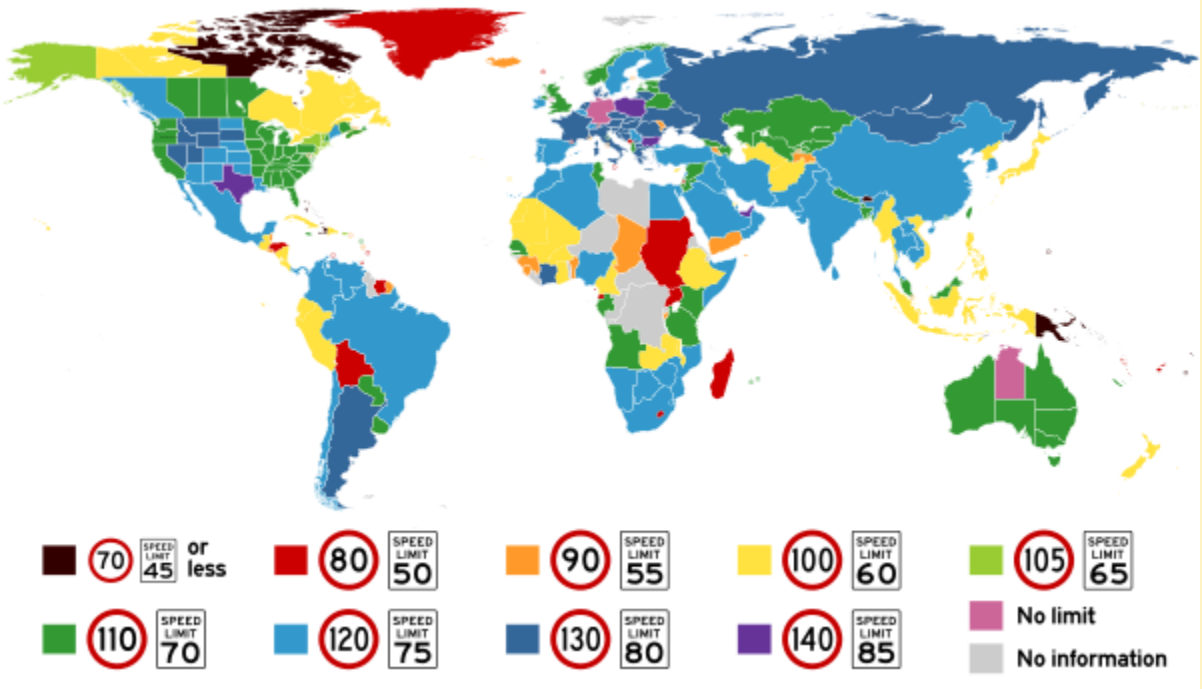
Section Objectives

Upon completion of this section, you will be able to identify allowable transport limits and unacceptable transport conditions for radioactive material.

Additional Transportation Requirements and Limitations – cont.

General Requirements and Limitations

(See Student Manual, page 123)



Additional Transportation Requirements and Limitations – cont.

Package Radiation Level and Transport Index Limits

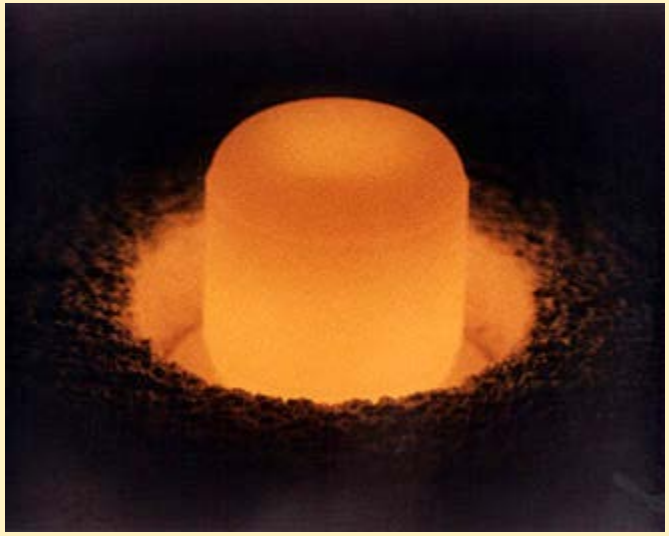
(See Student Manual, page 124)

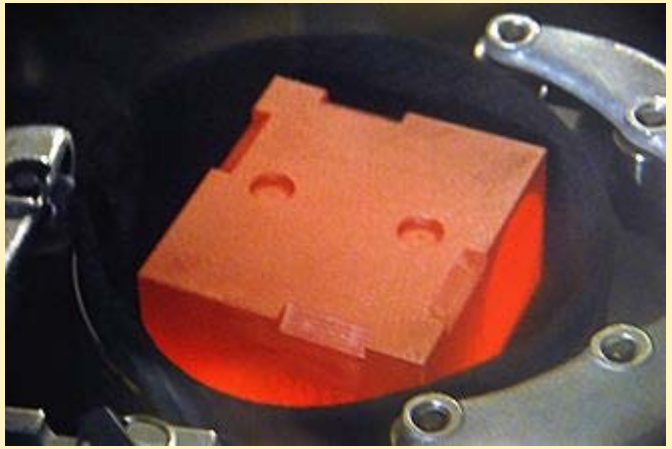
- Radiation level cannot exceed 2 mSv/h (200 mrem/h) on any package surface
- TI cannot exceed 10

Additional Transportation Requirements and Limitations – cont.

Package Thermal Limits

(See Student Manual, page 124)





Additional Transportation Requirements and Limitations – cont.

Package Surface Contamination Limits

Maximum Permissible Limits			
Contaminant	**Bq/cm²**	**µci/cm²**	**dpm/cm²**
Beta and gamma emitters and low-toxicity alpha emitters	4	10^{-4}	240
All other alpha-emitting radionuclides	0.4	10^{-5}	24

Additional Transportation Requirements and Limitations – cont.

Loading
and
Unloading Requirements
177.842
(See Student Manual, page 126)

- TI ≤ 50
- Minimum separation distance between packages
- Minimum separation distance between packages, people, animals, and undeveloped film (transit time)

Additional Transportation Requirements and Limitations – cont.

Segregation
and
Separation of
Hazardous Materials

177.848

(A detailed discussion of these requirements is provided in course HMPT: Movement by Highway LIVE)

Additional Transportation Requirements and Limitations – cont.

Perform Self-Assessment in Student Manual

(Page 129)

HMPT: Basic Radioactive Material
Course 30462

Please complete the class evaluation before leaving to take the TEST, Wednesday afternoon.