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HMPT: Basic Radioactive Material Transportation

Live #30462

Test #30463

February 2016

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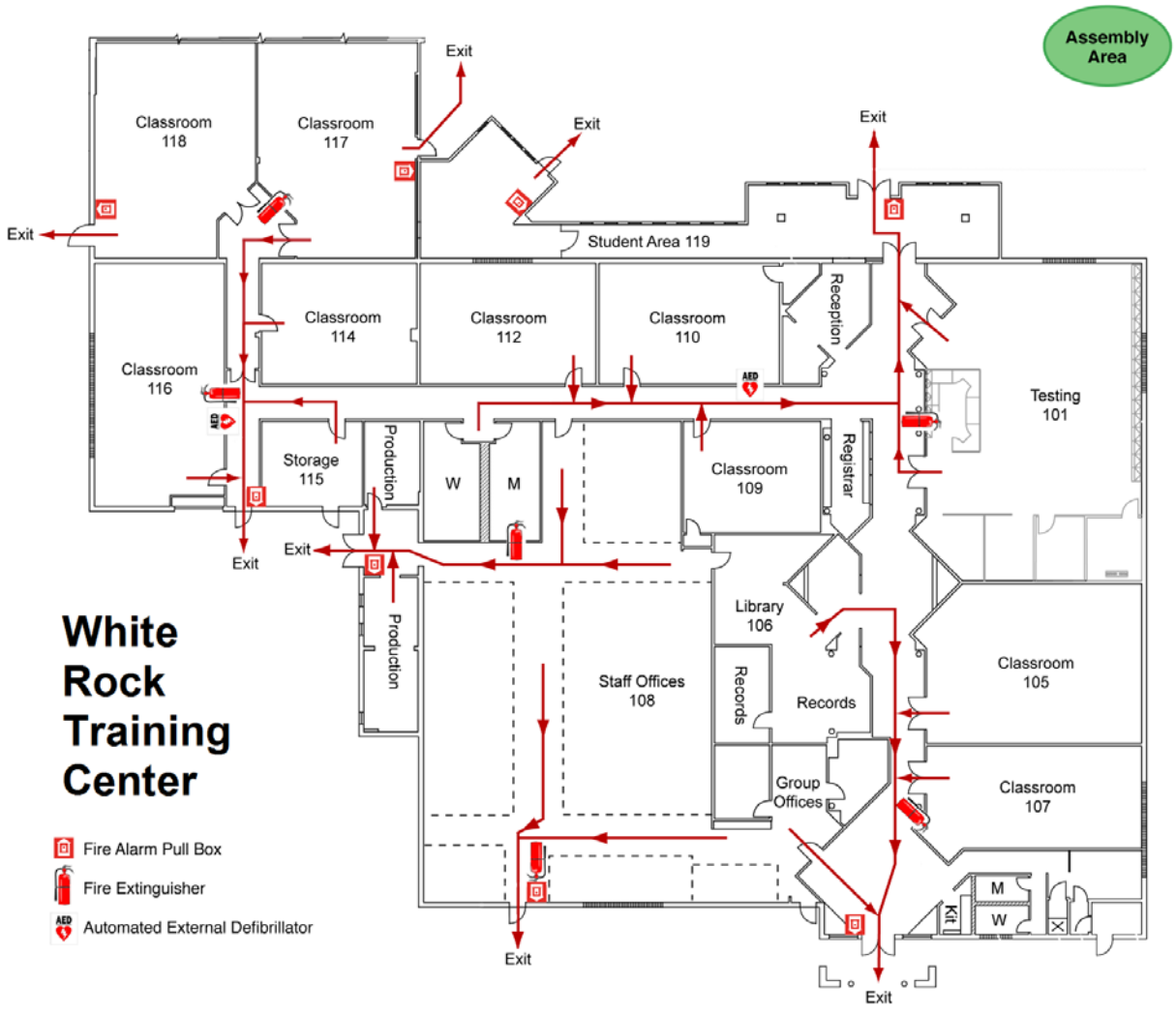

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Contents

Introduction

Course Overview

Hazardous Materials and Packaging and Transportation (HMPT): Basic Radioactive Material Transportation Live (#30462, suggested one time) and Test (#30463, required initially and every 36 months) address the Department of Transportation's (DOT's) function-specific [required for hazardous material (HAZMAT) handlers, packagers, and shippers] training requirements of the HMPT Los Alamos National Laboratory (LANL) Labwide training. This course meets the requirements of 49 CFR 172, Subpart H, Section 172.704(a)(ii), Function-Specific Training.

Course Objectives

After completing this course, you will be able to

- recognize and use standard international and United States (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 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's proper shipping name for a given material;
- determine when a single radionuclide quantity meets the DOT's definition of a hazardous substance;
- determine the appropriate packaging required for a given quantity of 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;

Course Objectives—continued

- identify the entry requirements for radioactive material label(s);
- 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; and
- 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; and
- is responsible for the safety of transporting hazardous materials.

Target Audience—continued

The table below defines specific HMPT training modules.

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), *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

Unless otherwise specified, this training pertains only to the transportation by highway of *nonbulk packages* of hazardous waste material. Nonbulk packagings have a maximum capacity of ≤450 L (119 gal.) for a liquid or a maximum net mass of ≤400 kg (882 lb) for a solid or water capacity >454 kg (1000 lb) as a receptacle for gas.

Instruction is limited to radioactive material containing a single, known radionuclide. Shipping requirements for low-specific-activity (LSA) material, surface-contaminated objects (SCOs), and material containing radionuclide mixtures or unknown radionuclides are addressed in *HMPT: Advanced Radioactive Material Transportation Live*.

This course does not address, to any significant extent, the packaging and shipping requirements for hazardous materials other than Class 7 material. HAZMAT employees who package or offer for transport hazardous materials other than Class 7 (radioactive) material will require additional training.

Course Limitations—continued

Note: *Additional requirements for the transportation of hazardous materials, radioactive material, and explosives are addressed in other courses and may be required for specific jobs.*

The HAZMAT employer is responsible for ensuring that each designated HAZMAT employee receives the training required to perform his or her function. HAZMAT employees are responsible for keeping their supervisors or managers informed of their current training status.

Course Prerequisites

The following courses either are a prerequisite or are recommended before taking this course:

- HMPT: Introduction (Suggested LIVE 27916, Required TEST 27917).
- HMPT: Identification of Hazardous Materials (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

To earn credit in the UTrain Learning Management System for the live class (#30462), you must attend a class and sign a roster.

To earn credit in UTrain for the TEST (#30463) given at the end of this course or at a proxied site, you must score 80% or better on the test.

Department of Transportation Training Requirements

Title 49 CFR Part 172.700 (Subpart H), “Training,” defines the training required by the DOT for all workers who handle, package, and/or transport hazardous materials.

The DOT has divided its training requirements into the following six areas:

- General Awareness/Familiarization—required for all HAZMAT employees (172.704[a][1]).
- Function Specific—required for HAZMAT handlers, packagers, and shippers (172.704[a][2]). This course, *HMPT: Basic Radioactive Material Transportation*, is the first of two courses required to meet the function-specific training requirements for those HAZMAT employees who are responsible for the packaging and transport of Class 7 (radioactive) material other than radioactive waste.
- Safety—required for all HAZMAT employees except packaging engineers (172.704[a][3]).
- Security Awareness—required for all HAZMAT employees (172.704[a][4]).
- In-Depth Security—required for all LANL HAZMAT employees (172.704[a][5]).
- Driver—required for anyone who transports hazardous materials by highway (177.816).

HMPT: Basic Radioactive Material Transportation Live provides instruction on the following quantities of radioactive material:

- Highway-route-controlled quantities (HRCQs),
- Type-B quantities,
- Type-A quantities,
- limited quantities, and
- reportable quantities (RQs).

Department of Transportation Training Requirements—continued

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.

Acronyms

ACEM	activity concentration for exempt material
ALARA	as low as reasonably achievable
ALEC	activity limit for exempt consignment
CFR	Code of Federal Regulations
CSI	criticality safety index
DOE	Department of Energy
DOT	Department of Transportation
HAZMAT	hazardous material
HMPT	hazardous materials packaging and transportation
HMT	Hazardous Materials Table
HRCQ	highway-route-controlled quantity
IAEA	International Atomic Energy Agency
LANL	Los Alamos National Laboratory
LSA	low specific activity
NRC	Nuclear Regulatory Commission
PSN	proper shipping name
rem	roentgen equivalent man

Acronyms—continued

RQ	reportable quantity
SCO	surface-contaminated object
SI	Systeme Internationale or International System of Units
TI	transport index
UK	United Kingdom
UN	United Nations
US	United States

Notes . . .

Overview of Class 7 (Radioactive) Material

Regulation of Radioactive Material Transportation

In the Department of Energy (DOE) complex, the transportation of radioactive material is governed by three federal agencies. The DOT regulates the transportation of hazardous and radioactive material through 49 CFR. The Nuclear Regulatory Commission (NRC) provides, in 10 CFR 71, regulations for the packaging of Type-A fissile material, Type-B radioactive material, and fissile material and fissile material exceptions. The DOE regulates the movement of radioactive material within the DOE complex through DOE Orders and the DOE Radiological Control Standard and retains the authority to approve Type-B packagings. These regulations are the result of more than 60 years of experience in the transport of radioactive material.

Regulation of radioactive material transportation began in the early 1930s. When radioactive materials were transported together, they were found to be capable of clouding photographic film. As a result, the US Postal Service implemented the first transportation regulations for radioactive material, and the Railway Express Agency installed segregation requirements.

In 1947, regulations governing the transport of radioactive material, which had developed independently under many different agencies, were adopted by and consolidated under the Interstate Commerce Commission. Additional regulations were developed by the Atomic Energy Commission and were formalized by the adoption of 10 CFR for special nuclear material in 1958.

International regulation began in the early 1960s, when the International Atomic Energy Agency (IAEA) began publishing regulations for the transport of international shipments of radioactive material. To ensure consistency, the DOT periodically adopts additional international regulations and publishes them in 49 CFR. In this way, international regulations have become the basis for the current US regulations governing the transport of radioactive material.

Regulation of Radioactive Material Transportation—continued

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

DOT Hazard Classes

Radioactive material is only one of nine different DOT hazard classes. Some of these hazard classes are further divided into divisions. The hazard class/divisions are identified by numbers and are listed in 49 CFR 173.2. DOT regulations provide basic requirements that apply to all hazardous materials. Additional specific requirements may apply to an individual hazard class.

40 CFR 173 Subpart I is devoted to specific regulations that govern the transport of radioactive material. Subpart I provides

- definitions,
- packaging descriptions and design requirements, and
- criteria for Class 7 (radioactive) material.

49 CFR 172 provides

- shipping paper requirements (Subpart C),
- marking requirements (Subpart D), and
- labeling requirements (Subpart E).

Unique Hazards of Radioactive Material

Radioactive material poses unique hazards to personal health and safety. These unique hazards result from the emission of energy or energetic subatomic particles by radioactive material. Referred to as ionizing radiation, these emissions can exhibit various characteristics. Specific characteristics associated with any given form of radiation determine the hazards posed by the form of radiation.

Unique Hazards of Radioactive Material—continued

One important characteristic of ionizing radiation is the distance it can travel from its source. Some forms of ionizing radiation can travel through many feet or even yards of air. Ionizing radiation may even pass through material commonly used for packaging, such as paper, cardboard, plastic, wood, or steel. Because of the distance that ionizing radiation can travel and because of its ability to penetrate material, radioactive material may pose a health hazard even to individuals who are not in direct contact with the radioactive material itself.

ALARA and the Transportation of Radioactive Material

As low as reasonably achievable (ALARA) forms the philosophical basis for the regulations governing the transportation of radioactive material. This philosophy dictates that exposures associated with the transportation, packaging, and handling of radioactive material be kept ALARA. This philosophy applies to each material and to each shipment.

Radiation exposure depends on

- time,
- distance, and
- shielding.

To suffer health effects from radiation, a person must be exposed to the radiation. Reducing the duration of exposure can reduce radiation exposures. Increasing the distance and/or the amount of shielding between the person and the radiation source can also reduce exposures.

The risks normally associated with radioactive material can become even greater through contamination, which occurs when radioactive material is unintentionally released from its containment (i.e., package). When the release of radioactive material results in personal contamination, the risk of radiation exposure increases. Personal contamination is most serious when it results from the ingestion, injection, or inhalation of radioactive material into the body. Under these circumstances, the ionizing radiation given off by the radioactive material has an increased opportunity to affect the body's internal cells.

Lessons Learned—United Kingdom (UK)

Attention to detail is critical in nuclear operations in general and in radioactive material shipments in particular. This need is illustrated by the following selections from the 2011 UK report, "Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK—2011 Review": https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/340136/HPA-CRCE-037_for_website.pdf. These selections also show the uniformity of the terminology and concepts of radioactive material shipments around the world.

2011001 During security screening at an airport, a consignment was found to contain smoke detectors. The consignment was marked and labeled as dangerous goods but not declared as being an excepted package on the air waybill. The consignor and carrier investigated the event and found that the consignor had failed to declare the consignment correctly and that the carrier had not inspected the package upon collection. Extra training of the carrier staff was suggested.

2011002 A package containing 100 kBq of a sample of ^{226}Ra was incorrectly consigned as exempted material, when it should have been sent in an excepted package. The consignor carried out an internal investigation.

2011011 On arrival in the UK, a Type-B package approved in the Czech Republic and containing a spent source was found to have been tampered with. On close inspection it was found that the tamper-proof seal was intact but that lid nuts were missing from the outer packaging. The outer packaging offered only thermal protection, whereas the inner packaging offered containment. The consignee requested information about the condition of the package on its leaving from the overseas consignor. It was found also that the date of the approval certificate for the innermost containment package had lapsed.

Lessons Learned—United Kingdom (UK)—continued

2011014 A consignment of 22 drums, each containing a small quantity of fissile material mixed with water and oil, was sent from a nuclear facility to a fuel manufacturing plant. On arrival, it was found that the fissile exception limit was exceeded for one of the drums. The drums were industrial packages with LSA Category II that were approved by the consignor. On investigation, a discrepancy was found between the drum scanner at the nuclear facility and checks made by the nuclear fuel manufacturing plant.

2011027 Four portable radiography instruments were shipped as an excepted package from a nuclear power station to a company for calibration. Following calibration, the consignment was dispatched back to the nuclear power station via a normal courier route rather than as it had been received, as an excepted package. Corrective actions were taken to ensure that this mistake did not occur again.

2011035 A courier van carrying excepted packages to a nuclear site was stopped by police for a routine check. It was discovered that the driver was disqualified from driving. The packages were subsequently delivered by another driver from the same courier company.

2011035 A nuclear site reported to an emergency company that a flask that had been consigned by them containing graphite samples had been received with the lid bolts not to the correct torque. An investigation was carried out by the energy company.

Notes . . .

Units of Measure for Radioactive Material

Objective

Upon completing this module, you will be able to recognize and use standard international and US customary units to describe activities and exposure rates associated with radioactive material (Objective 1).

SI Units of Measure

To ensure compatibility with international transportation standards, the DOT requires shippers to use the Systeme Internationale or International System of Units (SI). Most units of measure in 49 CFR 171–180 are expressed in SI units. Where SI units appear, they are the regulatory standard. US standard or customary units appearing in parentheses following SI units are presented for informational purposes [49 CFR 171.10(a)].

The activity in a 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 are generally indicated by their abbreviations [49 CFR 171.10(b)], which are provided in 49 CFR 171.10(c). Some of the more common SI units and their abbreviations are provided in the following table.

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	becquerel	Bq
ionizing radiation dose	sievert	Sv

SI Unit Prefixes

An important feature of SI units is the provision for modifying the standard units, through the use of multiplicative prefixes, to express either very small or very large quantities. Standard SI prefixes and their numerical values are provided in the following table.

SI Unit 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	p	0.000 000 000 001	10^{-12}

The SI unit of mass is the gram. Regardless of the specific unit, SI prefixes act as “multipliers.” So 1 kilogram is equal to 1000 grams (g), and the abbreviation is 1 kg. This use of prefixes is identical for all SI units: 1 kg equals 1000 g, and 1 kBq equals 1000 becquerels.

Similarly, 1 teragram can be used to indicate 1 trillion grams. The abbreviation for tera is “T,” and the abbreviation for gram is “g,” so 1,000,000,000,000 grams can be written as 1 Tg.

Some values in this manual and in the regulations are expressed in scientific notation. Scientific notation takes the form “a.aa x 10^{b}” or “a x 10^{b}.” The “b” values are exponents as shown in the table above. To calculate a value from scientific notation, multiply 10 by itself “b” times, and then multiply that number by the “a” value. So 6 x 10^{3} is 6 x (10 x 10 x 10), which is 6 x 1000, which is 6000.

Conversion between SI Standard Units

The table above on SI unit prefixes can also be used to convert the representation of a quantity from one prefix to a different, more convenient prefix. For instance, 1 kilogram (kg) is the same as 1,000,000 milligrams (mg).

Conversion between SI Standard Units—continued

In using this table, remember that decimal conversions can be a "down-right" or "up-left" experience. To convert kilograms into milligrams, move down the table and move the decimal point to the right (down-right). Each step down the table represents a difference of a power of three (1000 times smaller). For each power difference, the decimal point must be moved one position to the right. Therefore, for each step down the table, the decimal point must be moved three positions to the right, as indicated below.

1.0 kg	
1,000.0 g	down one prefix, right three positions
1,000,000.0 mg	down one prefix, right three positions

Or

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

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

Similarly, to convert 1 mg to megagrams, move the decimal point to the left ("up-left"). The difference between milligrams and megagrams is a power of nine (three prefix positions in the table). Therefore, the decimal position must be moved nine positions to the left to convert from milligrams and megagrams, as indicated below.

0.000 000 001 Mg	up one prefix, left three positions
0.000 001 kg	up one prefix, left three positions
0.001 g	up one prefix, left three positions
1 mg	

Or

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

$$0.001\ g = 0.001\ g\left[\frac{kg}{100\ g}\right] = 0.000\ 001\ kg$$

Conversion between SI Standard Units—continued

Activity 1: Conversion between SI Standard Units
(Answers on page 24)

Given the number of units in column A, provide the corresponding values for the units in column B.

Column A	Column B
1 g	mg
1 g	μg
1 g	kg
1 Mg	g
1 Gg	kg
1 Gg	Tg
1 Gm	Tm
1 Mm	Tm
1 mm	Mm

Units of Activity

The amount of activity in a radioactive material can be expressed in either becquerels or curies. The becquerel is the standard SI unit of activity and is the standard unit of activity for the DOT. The curie is the standard US customary unit of activity. Both unit systems indicate the number of radioactive disintegrations that occur within a fixed time interval.

1 Bq of activity = 1 disintegration per second.

1 Ci of activity = 37 billion disintegrations per second.

Conversion between US Customary and SI Units of Activity

Curies are commonly used in areas that are not regulated by the DOT. It is important to be able to convert curies to becquerels.

A becquerel is a relatively small unit of activity (one radioactive disintegration per second). A curie is a relatively large unit of activity (37,000,000,000 radioactive disintegrations per second).

1 Ci = 37 billion Bq.

Because the becquerel is such a small unit of activity, it is frequently more convenient to use a unit indicating a large number of becquerels. One such unit is the terabecquerel.

1 terabecquerel = 1 trillion becquerels = 1TBq = 1 x 10^{12} Bq.

A terabecquerel is even larger than a curie.

1 Tbq = 27 Ci.

The following table illustrates the relationship between SI and US customary units of activity.

Comparison of SI and US Customary 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 between US Customary and SI Units of Activity—continued

The following equation can be used to convert from curies to terabecquerels:

(number of Ci) Ci × 0.037 TBq/Ci = (number of TBq) TBq.

For example,

5 Ci × 0.037 TBq/Ci = 0.185 TBq, and

30 Ci × 0.037 TBq/Ci = 1.1 TBq.

Alternatively, because there are 27 Ci in 1 TBq, the following equation may be used:

(number of Ci) Ci ÷ 27 Ci/Tbq = (number of TBq) TBq.

For example,

5 Ci ÷ 27 Ci/TBq = 0.185 TBq, and

30 Ci ÷ 27 Ci/TBq = 1.1 TBq.

Activity 2: Conversion between US Customary and SI Units of Activity (Answers on page 24)

Given the number of units in column A, provide the corresponding values for the units in column B.

Column A	Column B
1 Ci	TBq
27 Ci	TBq
27 Ci	GBq
1 μCi	TBq
108 mCi	TBq

Units of Radiation Exposure

Radioactive material releases energy in the form of ionizing radiation, which can be harmful to humans. The health effects of ionizing radiation depend (among other factors) on the amount of energy absorbed by matter exposed to ionizing radiation. The amount of energy absorbed is known as the exposure, or dose. The biological effects of ionizing radiation depend on the size of the dose received. Radiation doses are routinely described in units that are corrected for their biological impact, or effectiveness.

In US customary units, radiation doses adjusted for biological effectiveness are measured in roentgen equivalents in man (rems). In SI units, the standard unit of measure for radiation dose, adjusted for biological effectiveness, is the sievert. The DOT standard unit for dose is the sievert.

Conversion between US Customary and SI Units of Radiation Exposure

The rem is commonly used in activities and operations not regulated by the DOT. It is important to be able to convert rems to sieverts.

In performing conversions, remember that the sievert is a larger unit than the rem.

1 Sv = 100 rem.

0.01 Sv/h = 1 rem/h

The following equations can be used to convert rems to sieverts:

(number of rem) rem ÷ 100 rem/Sv = (number of Sv) Sv, or

(number of rem) rem × 0.01 Sv/rem = (number of Sv) Sv.

For example,

1 rem ÷ 100 rem/Sv = 0.01 Sv, and

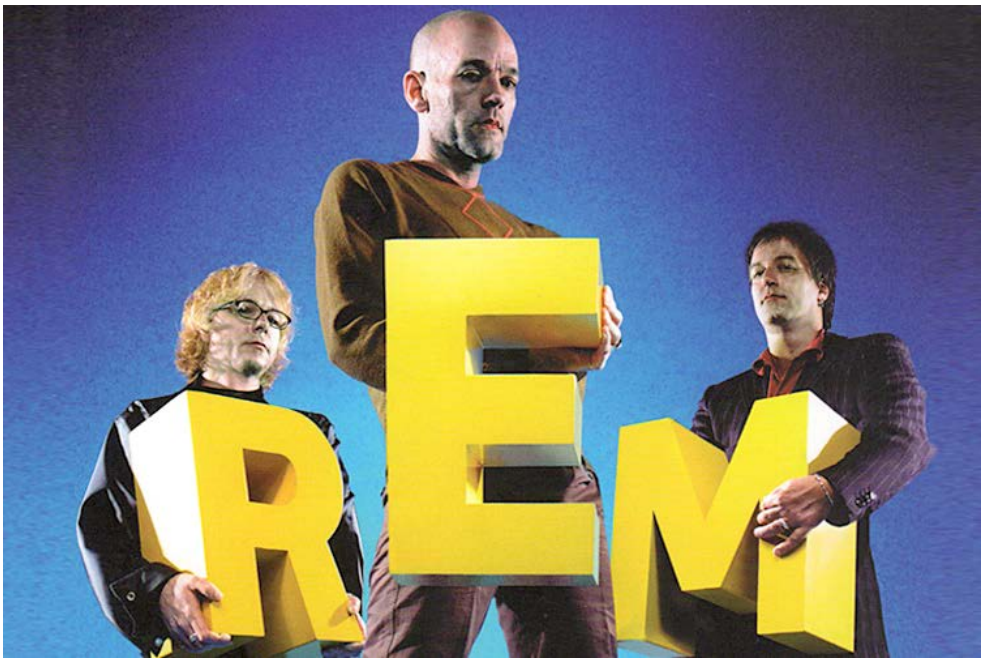
50 rem × 0.01 Sv/rem = 0.50 Sv.

Conversion between US Customary and SI Units of Radiation Exposure—continued

Activity 3: Conversion between US Customary and SI Units of Exposure (Answers on page 24)

Given the number of units in column A, provide the corresponding values for the units in column B.

Column A	Column B
125 rem	Sv
0.001 rem	Sv
1000 rem	kSv
1 mrem	Sv



Self-Assessment

1. Perform the following conversions between SI units.
   a. 0.1895 TBq = GBq
   b. 0.0005 TBq = MBq
   c. 0.919 kBq = Bq
   d. 1968 kBq = MBq
   e. 1927Bq = mBq
   f. 0.031 Sv = mSv
   g. 19.45 mSv = Sv
   h. 0.76 Sv = mSv
2. Perform the following conversions from US customary to SI units.
   a. 62.13 Ci = TBq
   b. 0.293 mCi = GBq
   c. 7.8 mCi = MBq
   d. 3674.1 mCi = TBq
   e. 8.12 Ci = GBq
   f. 0.021 rem = Sv
   g. 1.2 mrem = mSv
   h. 32.1 mrem = Sv
   i. 32.1 rem = mSv
3. Perform the following conversions from SI to US customary units.
   a. 8.72 GBq = Ci
   b. 56.4 MBq = mCi
   c. 0.00843 GBq = mCi

Answers to Activities

Activity 1: Conversion between SI Units

Column A	Column B
1 g	1000 mg
1 g	1,000,000 μg
1 g	0.001 kg
1 Mg	1,000,000 g
1 Gg	1,000,000 kg
1 Gg	0.001 Tg
1 Gm	0.001 Tm
1 Mm	0.000 001 Tm
1 mm	0.000 000 001 Mn

Activity 2: Conversion between US Customary and SI Units of Activity

Column A	Column B
1 Ci	0.037 TBq
27 Ci	1 TBq
27 Ci	1000 GBq
1 μCi	0.000 000 037 TBq
108 mCi	0.004 TBq

Activity 3: Conversion between US Customary and SI Units of Radiation Exposure

Column A	Column B
125 rem	1.25 Sv
0.001 rem	0.000 01 Sv
1000 rem	0.01 kSv
1 mrem	0.000 01 Sv

Answers to Self-Assessment

1. Perform the following conversions between SI units.
   a. 0.1895 TBq = 189.5 GBq
   b. 0.0005 TBq = 500 MBq
   c. 0.919 kBq = 919 Bq
   d. 1968 kBq = 1.968 MBq
   e. 1927 Bq = 1,927,000 mBq
   f. 0.031 Sv = 31 mSv
   g. 19.45 mSv = 0.01945 Sv
   h. 0.76 Sv = 760 mSv

2. Perform the following conversions from US customary to SI units.
   a. 62.13 Ci = 2.30 TBq
   b. 0.293 mCi = 0.01 GBq
   c. 7.8 mCi = 288.6 MBq
   d. 3674.1 mCi = 0.136 TBq
   e. 8.12 Ci = 300.44 GBq
   f. 0.021 rem = 0.00021 Sv
   g. 1.2 mrem = 0.012 mSv
   h. 32.1 mrem = 0.00032 Sv
   i. 32.1 rem = 321 mSv

3. Perform the following conversions from SI to US customary units.
   a. 8.72 GBq = 0.236 Ci
   b. 56.4 MBq = 1.52 mCi
   c. 0.00843 GBq = 0.228 mCi

Notes . . .

Definition of Class 7 (Radioactive) Material

Objective

Upon completing this module, you will be able to determine whether a quantity of a single radionuclide meets the definition of Class 7 (radioactive) material (objective 2).

Class 7 (Radioactive) Material

Definitions pertaining to the transport of Class 7 (radioactive) material are presented in 49 CFR 173.403.

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

- *Radioactive material* means any material containing radionuclides where both the activity concentration *and* the total activity in the consignment exceed the values specified in the table in 49 CFR 173.436 or the values derived according to the instructions in 49 CFR 173.433. Both the activity concentration and the total activity must exceed the CFR values.

To fully understand the DOT definition for radioactive material, it is necessary to understand the meaning of specific activity, which is defined in 49 CFR 173.403.

- *Specific activity* of a radionuclide means the activity of the radionuclide per unit mass of that radionuclide. The specific activity of a material in which the radionuclide is essentially uniformly distributed is the activity per unit mass of the material.

The definition of radioactive material depends on the specific activity of the material, not the specific activity of the radionuclide.

What Is Not Class 7 (Radioactive) Material?

DOT regulations do not apply to all radioactive material. 40 CFR 173.401(b) lists the following materials that are not regulated by the DOT:

(1) radioactive material that is not in the process of being transported

What Is Not Class 7 (Radioactive) Material?—continued

(2) radioactive material in a person or live animal for diagnosis or treatment, such as a person or pet who has received radioactive iodine for thyroid cancer treatment

(3) radioactive material that is an integral part of the means of transport, such as thorium in the turbine blades of a helicopter

(4) Natural material and ores containing naturally occurring radionuclides that are either in their natural state or that have been processed only for purposes other than extraction of the radionuclides, such as granite countertops that contain low levels of natural uranium.

(5) Nonradioactive solid objects with surface contamination below the threshold limits set forth in the definition of contamination in §173.403.

Exempt vs Excepted

Some materials are *exempt* from regulation. These materials are not regulated simply on the basis of their radioactivity. Exempt means that the regulator and shipper can essentially ignore the fact that the material is radioactive. Exempted is a stronger term than excepted.

Other materials are *excepted*. Excepted has a narrower, more limited meaning. Excepted materials are regarded as radioactive for regulatory purposes; however, some of the requirements are applied to shipments or consignments of high concentrations or higher total activity. See 49 CFR 173.424 and 173.425 for regulations that apply to excepted materials.

Activity Concentration Limits for Exempt Material

There are two criteria for determining whether a material meets the definition of a Class 7 (radioactive) material. One is the activity concentration (Bq/g) for exempt material. The second is discussed in the next section, Activity Limit for Exempt Consignment. If a radioactive-material-specific activity is equal to or less than the radionuclide activity concentration for exempt material (ACEM) (Bq/g) per 49 CFR 173.436, 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.

Activity Concentration Limits for Exempt Material—continued

The Table of Exempt Material Activity Concentrations and Exempt Consignment Activity Limits is organized as follows (49 CFR 173.436):

- The first column provides a list of radionuclides by symbol.
  - The symbols are listed in alphabetical order.
  - Radionuclides of the same element are then listed by atomic mass.
- The second column provides the elemental name and atomic number. The full name of each element is listed in alphabetical order. The atomic number is listed in parentheses by the name of the element.
  ***Note**: Tritium is denoted in the table as "T(H-3)."*
- The third and fourth columns provide the ACEM for each radionuclide. Activity concentration is an expression of how much radioactivity is spread through the total mass of the material.
  - The activity concentration value for exempt material provides the activity concentration limit (maximum number of becquerels per gram) for a material that is exempt from 49 CFR Class 7 DOT hazardous materials requirements.
  - The activity concentration values are indicated in both SI units (Bq/g: column 3) and US customary units (Ci/g: column 4). For example, the activity concentration value for ^{137}Cs is 1×10^{1} Bq/g (2.7×10^{-10} Ci/g).
  - The activity concentration limit value is provided in scientific notation. For example, the activity concentration for ^{131}Ba is 1×10^{2} Bq/g (2.7×10^{-9} Ci/g).
- The fifth and sixth columns provide the activity concentration for exempt consignments for each radionuclide. Consignments and these quantities are discussed further on page 31.

Activity Concentration Limits for Exempt Material—continued

Activity 4: Determination of Activity Concentration Exempt Values (Answers on page 36)

Provide activity concentration exempt values in SI units.

Example: What is the activity concentration exempt value for ^{10}Be?

Activity concentration exempt value = 1×10^4 Bq/g

Example: What is the activity concentration exempt value for ^{243}Cm?

Activity concentration exempt value = 1.0 Bq/g

1. What is the activity concentration value for ^{134}Cs?

2. What is the activity concentration value for ^{64}Cu?

3. What is the activity concentration value for ^{166}Ho?

4. What is the activity concentration value for ^{55}Fe?

Activity Limit for Exempt Consignment

The second of the two criteria for determining whether a material meets the definition of a Class 7 (radioactive) material is the activity limit for exempt consignment (ALEC). This is an activity, so it is expressed in becquerels. If the consignment radioactive material activity is equal to or less than the radionuclide activity concentration for exempt consignment (becquerels) per 49 CFR 173.436, 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.

The DOT defines consignment in 49 CFR 173.403:

- *consignment* means a package or group of packages or a load of radioactive material offered by a person for transport in the same shipment.

The Table of Exempt Material Activity Concentrations and Exempt Consignment Activity Limits is organized as follows (49 CFR 173.436):

- Columns 5 and 6 provide the activity limit values for exempt consignment for each radionuclide.
  - The activity limit value for exempt consignment (maximum becquerels) provides the per-consignment limit that is exempt from 49 CFR Class 7 DOT hazardous materials requirements.
  - The activity limit values for exempt consignment are indicated in both SI units (Bq: column 5) and US customary units (Ci: column 6). For example, the activity limit value for ^{137}Cs is 1×10^{4} Bq, or 2.7×10^{-7} Ci.
  - The activity limit value for exempt consignment is provided in scientific notation. For example, the activity limit value for ^{131}Ba is 1×10^{6} Bq, or 2.7×10^{-5} Ci.

Recent Changes to 173.436 Exemption Values

Rule HM-250 made the following changes to the exemption values in the table of exempt material activity concentrations and exempt consignment activity limits for radionuclides:

- ^{121m}Te values have changed
- ^{79}Kr has been added to the table
- The list of parent/daughters in footnote (b) of the table has changed as follows

Recent Changes to 173.436 Exemption Values—continued

- Decay chains for ^{134}Ce, ^{220}Rn, ^{226}Th, and ^{240}U have been removed
- A decay chain for ^{108m}Ag has been added.

The Winter 2015 49 CFR or a more recent version will reflect these HM-250 changes.

Activity Limit for Exempt Consignment—continued

Activity 5: Determination of Activity Limit Values for Exempt Consignment (Answers on page 36)

Provide activity limit values for exempt consignment in SI units.

Example: What is the activity limit value for exempt consignment for ^{10}Be?

Activity limit value for exempt consignment = 1×10^6 Bq

Example: What is the activity limit value for exempt consignment for ^{239}Pu?

Activity limit value for exempt consignment = 1×10^4 Bq

1. What is the activity limit value for exempt consignment for ^{248}Cm?

2. What is the activity limit value for exempt consignment for ^{134}Cs?

3. What is the activity limit value for exempt consignment for ^{166}Ho?

4. What is the activity limit value for exempt consignment for ^{55}Fe?

Determination of DOT-Regulated, Class 7 (Radioactive) Material

Activity 6: Determination of DOT-Regulated, Class 7 Radioactive Material (Answers on page 34)

Determine whether the following materials are DOT-regulated, Class 7 radioactive material in transport.

1. 2.0 MBq of ^{28}Mg in 500 g of solution

2. One package with 0.75 GBq of T(H-3) in 5000 g of water

Self-Assessment

Determine whether the following materials are DOT-regulated Class 7 radioactive material in transport.

1. Three packages with 0.01 GBq of ^{99}Tc in 1200 g of water

2. One package with 0.20 GBq of ^{99}Tc in 400 g of water

Answers to Activities

Activity 4: Determination of Activity Concentration Exempt Values

1. Activity concentration value = 1 x 10^1 Bq/g
2. Activity concentration value = 1 x 10^2 Bq/g
3. Activity concentration value = 1 x 10^3 Bq/g
4. Activity concentration value = 1 x 10^4 Bq/g

Activity 5: Determination of Activity Limit Values for Exempt Consignment

1. Activity limit value for exempt consignment = 1 x 10^3 Bq
2. Activity limit value for exempt consignment = 1 x 10^4 Bq
3. Activity limit value for exempt consignment = 1 x 10^5 Bq
4. Activity limit value for exempt consignment = 1 x 10^6 Bq

Activity 6: Determination of DOT-Regulated, Class 7 Material

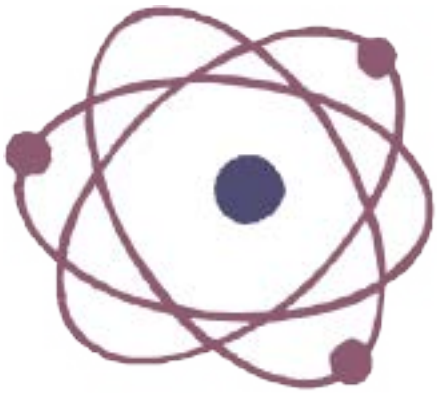
1. 2.0 MBq of ^{28}Mg in 500 g of solution

Activity Concentration Exempt Material Value (Regulations)	**Activity Concentration of Solution (Material in Transport)**
1.0 x 10^1 Bq/g	2.0 MBq ÷ 500 g = (2.0 x 10^6 Bq) ÷ (5.0 x 10^2g)
EXEMPT = 10 Bq/g	Material in Transport = 4000 Bq/g
EXEMPT is less than Material in Transport	
Package is NOT EXEMPT based on Activity Concentration	
ALEC (Regulations)	**Consignment Activity (Material in Transport)**
1.0 x 10^5 Bq	(1 pkg) (2.0 x 10^6 Bq/pkg)
EXEMPT = 1.0 x 10^5 Bq	Material in Transport = 2.0 x 10^6 Bq
EXEMPT is less than Material in Transport	
Consignment (package is NOT EXEMPT based on Consignment ALEC	
Therefore, because both criteria are NOT EXEMPT, the material is Class 7	

Answers to Activities—continued

2. One package with 0.75 GBq of T(H-3) in 5000 g of water

Activity Concentration Exempt Material Value (Regulations)	Activity Concentration of Solution (Material in Transport)
1.0×10^6 Bq/g	0.75 GBq ÷ 5000 g = $(0.75 \times 10^9$ Bq) ÷ $(5.0 \times 10^3$ g)
EXEMPT = 1,000,000 Bq/g	Material in Transport = 150,000 Bq/g
EXEMPT is greater than Material in Transport	
Package is EXEMPT based on Activity Concentration	
ALEC (Regulations)	**Consignment Activity (Material in Transport)**
1.0×10^9 Bq	(1 pkg) $(0.75 \times 10^9$ Bq/pkg)
EXEMPT = 1,000,000,000 Bq	Material in Transport = 750,000,000 Bq
EXEMPT is greater than Material in Transport	
Consignment (package) is EXEMPT based on Consignment Activity Limit	
Therefore, because either criterion (Activity Concentration or Activity Limit) is EXEMPT, the material is NOT Class 7.	



Answers to Self-Assessment

1. Three packages with 0.01 GBq of ^{99}Tc in 1200 g of water

Activity Concentration Exempt Material Value (Regulations)	Activity Concentration of Solution (Material in Transport)
1.0×10^4 Bq/g	0.01 GBq ÷ 1200 g = $(0.01 \times 10^9$ Bq) ÷ $(1.2 \times 10^3$ g)
EXEMPT = 10,000Bq/g	Material in Transport = 8334 Bq/g
EXEMPT is greater than Material in Transport	
Package is EXEMPT based on Activity Concentration	
ALEC (Regulations)	**Consignment Activity (Material in Transport)**
1.0×10^7 Bq/g	(3 pkg) $(0.01 \times 10^9$ Bq/pkg)
EXEMPT = 10,000,000 Bq	Material in Transport 30,000,000 Bq
EXEMPT is less than Material in Transport	
Consignment (three packages) is NOT EXEMPT based on Consignment Activity Limit	
Therefore, because one criterion (Activity Concentration) is EXEMPT, the material is NOT Class 7	

2. One package with 0.20 GBq of ^{99}Tc in 400 g of water

Activity Concentration Exempt Material Value (Regulations)	Activity Concentration of Solution (Material in Transport)
1.0×10^4 Bq/g	0..20 GBq ÷ 400 g = $(0.20 \times 10^9$ Bq) ÷ $(4.0 \times 10^2$ g)
EXEMPT = 100,000 Bq/g	Material in Transport = 500,000 Bq
EXEMPT is less than Material in Transport	
Package is NOT EXEMPT based on Activity Concentration	
ALEC (Regulations)	**Consignment Activity (Material in Transport)**
1.0×10^7 Bq	(1 pkg) $(0.20 \times 10^9$ Bq/pkg)
EXEMPT = 10,000,000 Bq	Material in Transport = 200,000,000 Bq
EXEMPT is less than Material in Transport	
Consignment (package) is NOT EXEMPT based on Consignment Activity Limit	
Therefore, because both criteria (activity concentration) are NOT EXEMPT, the material is Class 7	

Shipping Quantities for Radioactive Material

Objective

Upon completing this module, you will be able to determine, for a given single radionuclide, the shipping category activity limits per 49 CFR 173.435 (objective 3).

DOT Forms of Radioactive Material

For the purposes of shipping, the DOT groups radioactive material into two possible forms. Class 7 (radioactive) material is either special form or normal form.

The DOT defines special form and normal form in 49 CFR 173.403:

- *special form Class 7 (radioactive) material* means Class 7 (radioactive) material that satisfies the following conditions:
  - it is either a single, solid piece or is 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).
- *normal form Class 7 (radioactive) material* means Class 7 (radioactive) material that has not been demonstrated to qualify as special-form, Class 7 (radioactive) material.

In simple terms, if a Class 7 (radioactive) material is not in special form, then it is in normal form. Because special form is a robust, solid, or well-encapsulated material, there is less risk that it will be dispersed in an accident. Normal-form material is more likely to be dispersed and therefore poses a greater risk of contamination.

The DOT has recognized that shipments of radioactive material do not all pose the same level of risk. For instance, shipments of material with low activity pose far less risk than shipments with higher activity of the same material.

DOT Forms of Radioactive Material—continued

To accommodate the different risk levels, the DOT has established several categories for the shipment of radioactive material. Each quantity level provides specific packaging and transport controls. The following are examples of different shipping quantities for Class 7 (radioactive) material that will be discussed in this course:

- HRCQ,
- Type-B quantity,
- Type-A quantity, and
- limited quantity.

These quantities are the basis for different proper shipping names; they are also the basis for packaging, marking, labeling, placarding, and shipping paper requirements. The form of the radioactive material plays a crucial role in determining the appropriate shipping quantity and thus in determining all other requirements for the shipment.

Radionuclide “A” Values

When shipping a pure isotope (a material that contains only one radioactive isotope, although other nonradioactive material/chemicals may also be present), the DOT uses “A” values to define the available shipping categories. The first step in determining the shipping category for a radioactive material is to determine the form of the material. As discussed above, the form will be normal or special. Once the form has been determined, the “A” value for that material can be found.

“A” values have been assigned to most radionuclides and can be calculated for Class 7 (radioactive) material that consists of radionuclide mixtures. (The calculation of “A” values for radionuclide mixtures is covered in *HMPT: Advanced Radioactive Material Transportation Live*.)

“A” values reflect the potential risk, or level of hazard, associated with a radioactive material. These values depend not only on the form of the radioactive material, but also on the nature (types of radiation emission, half-life, etc.) of the radionuclide(s) contained in that material.

Radionuclide "A" Values—continued

In general, smaller "A" values mean that the material is more hazardous, and larger "A" values mean that the material is less hazardous. In other words, "A" values have an inverse relationship to the degree of hazard associated with a given radioactive material. "A" value amounts of different radioactive material pose similar levels of risk. Because "A" values have been used to define shipping categories for radioactive material, the level of hazard associated with a given shipping category is consistent, regardless of the radioactive material (isotope) being shipped.

The hazard posed by a Class 7 (radioactive) material, as previously indicated, depends not only on the radionuclide(s), but also on the form (special or normal) of the material. Because there are two possible forms for radioactive material, each radionuclide (or mixture of radionuclides) has two "A" values: one for each form. These "A" values are referred to as A_1 (special form) and A_2 (normal form).

The DOT defines A_1 and A_2 in Section 49 CFR 173.403:

- *A_1* means the maximum activity of special-form, Class 7 (radioactive) material permitted in a Type-
- A package.
- *A_2* means the maximum activity of Class 7 (radioactive) material, other than special form, LSA, or SCO, permitted in a Type A package.

Determination of Values for A_1 and A_2

The "A" values for most radionuclides are provided in 49 CFR 173.435, which contains the *Table of A_1 and A_2 Values for Radionuclides*.

The Table of A_1 and A_2 Values for Radionuclides is organized as follows:

- The first column provides a list of radionuclides by symbol.
  - The symbols are listed in alphabetical order.
  - Isotopes of the same element are then listed by atomic mass.
- The second column provides the elemental name and atomic number.

Determination of Values for A_1 and A_2—continued

  - The full name of each element is listed in alphabetical order. The atomic number is listed in parentheses by the name of the element.

- The third and fourth columns provide A_1 values for each radionuclide.
  - A_1 values indicate the maximum amount of special-form, Class 7 (radioactive) material that may be placed in a Type-A package.
  - A_1 values are indicated in both SI units (TBq: column 3) and US customary units (Ci: column 4). For example, the A_1 value for ^{137}Cs is 2 TBq (54.0 Ci).
- The fifth and sixth columns provide A_2 values for each radionuclide.
  - A_2 values indicate the maximum amount of normal-form (other than LSA and SCO), Class 7 (radioactive) material that may be placed in a Type-A package.
  - As with A_1 values, A_2 values are indicated in both SI units (column 5) and US standard units (column 6) and are frequently provided in scientific notation. For example, the A_2 value for ^{137}Cs is 6.0×10^{-1} TBq (1.6×10^{1} Ci).
- The seventh and eighth columns provide specific activities for each radionuclide.
  - The specific activity of the radionuclide indicates the amount of activity that would be found in 1 g of a pure radionuclide. For example, the specific activity of ^{241}Am is 3.4 Ci/g. A package that contains 0.34 Ci of pure ^{241}Am therefore would contain 0.1 g of ^{241}Am.
  - If the radionuclide is not pure, the specific activity will not provide a direct relationship between the activity and the total mass of the material contained in a package. For example, in an americium-beryllium neutron source, the amount of beryllium, which is not radioactive, can vary. The specific activity value given in column 7 or 8 cannot be used to calculate the total amount of radioactive AND nonradioactive material in the shipping container.

Determination of Values for A_1 and A_2—continued

Activity 7: Determination of Values for A_1 and A_2 (Answers on page 56)

Provide "A" values in SI units and indicate whether the value is an A_1 or A_2 value.

Example: What is the "A" value for ^{10}Be in special form?

$A_1 = 4.0 \times 10^1$ TBq = 40 TBq

Example: What is the "A" value for ^{239}Pu in normal form?

$A_2 = 1.0 \times 10^{-3}$ TBq = 0.001 TBq

1. What is the "A" value for ^{137}Cs in special form?

2. What is the "A" value for ^{137}Cs in normal form?

3. What is the "A" value for ^{236}Pu in normal form?

4. What is the "A" value for ^{185}W in special form?

The significance of "A" values becomes evident from observing how they are used to determine shipping categories.

Determination of Type-A and Type-B Quantities

Type-A and Type-B quantities are two of several possible shipping quantities for Class 7 (radioactive) material. Type-A and Type-B quantities differ from each other in the amount of material that is allowed in a single package. These types also differ in their packaging, marking, and shipping paper requirements.

Type-A and Type-B quantities are defined in 49 CFR 173.403:

- *Type-A quantity* means a quantity of Class 7 (radioactive) material, the aggregate radioactivity of which does not exceed ($\leq$) A_1 for special-form Class 7 (radioactive) material or A_2 for normal-form Class 7 (radioactive) material, where A_1 and A_2 values are given in 49 CFR 173.435 or are determined in accordance with 49 CFR 173.433.
- *Type-B quantity* means a quantity of material greater than a Type-A quantity. Type-B packages are therefore generally stronger and more carefully engineered and tested than Type-A packages.

Determination of Type-A and Type-B Quantities—continued

A Type-A quantity must be transported in a Type-A package, although a Type-B package is also allowed. A Type-B quantity exceeds the limits set for Type-A packaging and must be transported in a Type-B package. The table in 49 CFR 173.435 can be used to determine whether a Class 7 (radioactive) material is a Type-A or Type-B quantity.

Type-A and Type-B quantities are determined as follows:

- Determine the form (special or normal) of the material.
  - If the form is special, the activity limit is given by the A_1 value.
  - If the radioactive material is normal form, the activity limit is given by the A_2 value.
- Locate the radionuclide in the 49 CFR 173.435 table.
- Locate the appropriate "A" value for that form of that radionuclide.
- Compare the "A" value with the activity to be placed in a single package.

If the activity to be packaged in a single package is less than or equal to the listed A value, then it is a Type-A quantity. If the activity to be packaged is greater than the listed "A" value, then it is a Type-B quantity.

Activity 8: Determination of Type-A and Type-B Quantities
(Answers on page 56)

Use the table in 49 CFR 173.435 to determine whether the following activities of Class 7 (radioactive) material would constitute a Type-A or a Type-B quantity.

Example: 0.003 TBq of ^{237}Np in normal form.

Because the material is in normal form, the A_2 value applies in this case.

$A_2 = 2.0 \times 10^{-3}$ TBq, or 0.002 TBq

Because 0.003 TBq of ^{237}Np in normal form is greater than the A_2 value (2.0×10^{-3} TBq) for ^{237}Np, this amount of activity represents a Type-B quantity.

Example: 9 TBq of ^{201}Tl in special form.

Determination of Type-A and Type-B Quantities—continued

Because the material is in special form, the A_1 value applies.

$A_1 = 1.0 \times 10^1$ TBq

Because 9 TBq of ^{201}Tl in special form is less than the A_1 value (1.0×10^1 TBq) for ^{201}Tl, this amount of activity is less than a Type-A quantity and is therefore a Type-A quantity.

1. 5.0 TBq of ^{242}Cm in special form?

2. 1.0 TBq of ^{238}Pu in normal form?

3. 1.0 TBq of ^{33}P in normal form?

4. 5.0 MBq of ^{235}U in normal form?

5. 5.0 GBq of ^{254}Cf in normal form?

6. 50,000 GBq of ^{63}Ni in normal form divided equally between two packages?

Highway-Route-Controlled Quantities (HRCQs)

The term *highway-route-controlled quantity* (HRCQ) is the highest quantity for a given radionuclide in one package. As defined in 49 CFR 173.403:

- *HRCQ* means a quantity within a single package that exceeds
  - 3000 times the A_1 value of the radionuclide as specified in 49 CFR 173.435 for special-form Class 7 (radioactive) material;
  - 3000 times the A_2 value of the radionuclide as specified in 49 CFR 173.435 for normal-form Class 7 (radioactive) material; or
  - 1000 TBq (27,000 Ci);

  whichever is least.

An HRCQ determination is made as follows:

- Determine the form (special or normal) of the material.
- Determine the appropriate "A" value from the table in 49 CFR 173.435.
- Multiply the appropriate "A" value by 3000.
- If 3000 times the A_1 or A_2 value is <1000 TBq, then compare the package activity with 3000 x A. If 3000 times the A_1 or A_2 value is <1000 TBq, then compare the package activity with 1000 TBq.

If the activity of a given radionuclide in a single package is greater than either 1000 TBq (27,000 Ci) or 3000 times the "A" value, then that package contains an HRCQ of that radionuclide. HRCQs have special transport requirements.

Activity 9: Determination of HRCQs (Answers on page 57)

Use the table in 49 CFR 173.435 to determine whether the following activities of Class 7 (radioactive) material would constitute an HRCQ. Determine 3000 times the applicable "A" value, A_1 or A_2; then see which is smaller (that number or the 1000 TBq).

Example: 500 TBq of ^{10}Be in special form and transported in a single package.

Because the material is in special form, A_1 values apply.

$A_1 = 4.0 \times 10^1$ TBq

$(3000)(A_1) = (3000)(40\text{ TBq}) = 120{,}000$ TBq

Highway-Route-Controlled Quantities (HRCQs)—continued

1000 Tbq is <120,000 TBq

Because 500 TBq of ^{10}Be in special form is not greater than the smaller 1000-TBq value, 500 TBq is not an HRCQ.

Example: 4.0 TBq of ^{239}Pu in normal form and transported in a single package.

The material is in normal form and therefore is limited by A_2.

$A_2 = 1 \times 10^{-3}$ TBq

$(3000)(A_2) = (3000)(1 \times 10^{-3}\ \text{TBq}) = 3.0$ TBq

3 TBq is <1000 TBq

Because 4 TBq of ^{239}Pu in normal form is >3 TBq, the 4 TBq is an HRCQ.

1. 54,000 Ci of ^{132}Cs in normal form and transported in a single package.

2. 5.0 TBq of ^{228}Th in normal form and transported in a single package.

3. 600 TBq of ^{92}Y in normal form and transported in a single package.

4. 2 TBq of ^{231}Pa in normal form and divided equally between two packages.

Limited Quantities of Radioactive Material

The DOT uses a graded approach to its requirements for the shipment of hazardous materials. A limited quantity of Class 7 (radioactive) material is defined in 49 CFR 173.403:

- A *limited quantity of Class 7 (radioactive) material* means a quantity of Class 7 (radioactive) material not exceeding the material's package limits specified in 49 CFR 173.425 and conforming to the requirements specified in 49 CFR 173.421.

49 CFR 173.421 states, among other requirements, that the surface dose rate on a limited quantity package cannot exceed 0.5 mrem/h. An otherwise limited quantity that exceeds this value becomes a Type-A quantity.

As indicated in the definition, a limited quantity of Class 7 (radioactive) material must not exceed the activity limits specified in 49 CFR 173.425. These limits are listed in Table 4 of Part 173, Subpart I.

Table 4 is divided into four columns. The nature of the contents is indicated in the first column. Limits for instruments and articles are provided in the second and third columns. Shipments of instruments and articles must meet the limits given in both the second and third columns; this is discussed further below. Limits for Class 7 (radioactive) material other than instruments and articles are provided in the fourth column. This course will first examine the limits for radioactive material other than instruments or articles. The table on the following page presents portions of the first and fourth columns of Part 173, Subpart I, Table 4:

Limited Quantities of Radioactive Material—continued

Excerpts from Subpart I, Table 4, Columns 1 and 4	
Nature of Contents (Column 1)	**Material Package Limits (Column 4)**
Solids	
Special form	$10^{-3}A_1$
Normal form	$10^{-3}A_2$
Liquids	
Tritiated water	Depends on concentration
Other liquids	$10^{-4}A_2$
Gases	
Tritium	$2 \times 10^{-2}A_2$
Special form	$10^{-3}A_1$
Normal form	$10^{-3}A_2$

Activity limits for limited quantities of Class 7 (radioactive) material are determined, in part, by the nature of the material. The DOT sets 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); and
- the radionuclide (tritium or other).

For tritium in liquid water, the activity per unit volume is also considered.

The maximum activity for a limited quantity of solids or gases (other than tritium) in special form is 10^{-3} (0.001) times the A_1 value.

The maximum activity for a limited quantity of solids or gases (other than tritium) in other than special form (e.g., normal form) is 10^{-3} (0.001) times the A_2 value.

Limited Quantities of Radioactive Material—continued

The maximum activity for a limited quantity of a gas or a solid can be calculated with either of the two following equations (which are mathematically equivalent):

$(A_x) \times (0.001)$ = maximum activity for a limited quantity,

$(A_x) \div (1000)$ = maximum activity for a limited quantity,

where A_x is the appropriate "A" value.

For liquids (other than tritiated water), the maximum activity for a limited quantity is 10^{-4} (0.0001) times the A_2 value. This limit is 10 times lower than those set for solids and gases.

The maximum activity for a limited quantity of a liquid can be calculated with either of the two following mathematically equivalent equations:

$(A_x) \times (0.0001)$ = maximum activity for a limited quantity,

$(A_x) \div (10{,}000)$ = maximum activity for a limited quantity,

where A_x is the appropriate A value.

This course considers only limited quantities of Class 7 (radioactive) material containing a single radionuclide. Limited quantities of radioactive material containing more than one radionuclide are also permitted. The calculation of activity limits for radionuclide mixtures depends on the "A" values for these mixtures, which can be determined as prescribed in 49 CFR 173.433(d). These calculations are presented in *HMPT: Advanced Radioactive Material Transportation Live*.

Activity 10: Determination of Limited Quantities (Answers on page 57)

Use Table 4 in 49 CFR 173.425 to determine whether the following activities of Class 7 (radioactive) material would constitute a limited quantity:

Example: 1 GBq of solid ^{58}Co in special form and transported in a single package.

Because the material is special form, we use the A_1 value.

$A_1 = 1$ TBq

$(0.001)(A_1) = (0.001)(1 \text{ TBq}) = 0.001 \text{ TBq} = 1 \text{ GBq}$

$1 \text{ GBq} \leq 1 \text{ GBq}$

Therefore, the material <u>is</u> a limited quantity.

Limited Quantities of Radioactive Material—continued

Example: 900 MBq of dissolved (liquid) ^{45}Ca transported in a single package.

Because the material is a liquid, the A_2 value applies.

A_2 = 1.0 TBq

(0.0001)(A_2) = (0.0001)(1.0 TBq) = 0.000 1 TBq = 100 MBq

900 MBq > 100 MBq

Therefore, the material is <u>not</u> a limited quantity.

1. 3.5 MBq of ^{222}Rn gas in normal form and transported in a single package.

2. 0.002 TBq of ^{125}I in solution (liquid) and transported in a single package.

Activity Limits for Radioactive Instruments or Articles

Table 4 in 49 CFR 173.425 also provides limits for instruments or articles. 49 CFR 173.402 defines a radioactive instrument or article to mean “any manufactured instrument or article such as an instrument, clock, electronic tube or apparatus, or similar instrument or article having Class 7 (radioactive) material in gaseous or nondispersible solid form as a component part.” According to Section 173.424, the active material must be completely enclosed by nonactive components. A common example would be a smoke detector.

Shipments of instruments and articles must meet the activity limits in both column two and column three of Table 4 to qualify for shipment in excepted packages. Table 4 sets limits both on the activity associated with *each* instrument or article (in column 2) and on the *total* activity that may be contained within a single package (in column 3).

If one shipment had smoke detectors with built-in, special-form ^{241}Am check sources, the A_1 value would be 10 TBq (2.7 Ci). Table 4 tells us that the limit for each instrument or article is 0.01 times A_1, or 0.12 TBq. A single smoke detector typically has 37 kBq, or 0.037 MBq, or or 0.000037 GBq, or 0.00000037 TBq. Each of these instruments meets the column 2 requirement. Column 3 limits the activity to the A_1 value, or 10 TBq. For 0.00000037-TBq instruments, 27,027,027 instruments could therefore be placed in one package while meeting the Activity Limits for Limited Quantities, Instruments, and Articles. Adding one more instrument to total 27,027,028 of these instruments would exceed to the A_1 value; such a package would not be a limited quantity shipment. Clearly, 27,027,028 is an unrealistic number of instruments to put in one consignment, much less one package; this is a reflection of the fact that a smoke detector is a very safe device that uses a very, very small amount of radioactive material.

Activity limits for packages of instruments or articles and for the individual instruments or articles are calculated in the same manner as indicated above for other radioactive material. Care must be taken to ensure that calculations use the appropriate “A” value and activity limits.

Activity limits for instruments and articles contaminated with multiple or unknown radionuclides are addressed in *HMPT: Advanced Radioactive Material Transportation Live*.

Summary of Activity Limits for Radioactive Material Shipments

Materials are assigned to Class 7 based on their specific activity. Class 7 (radioactive) material (except LSA and SCO) is then categorized according to the amount of activity per package to be shipped. The following list summarizes the shipping quantities discussed in this section:

- Limited quantity of Class 7 (radioactive) material—material with an activity per package that does not exceed the limits in 49 CFR 173.425 and that meets certain additional criteria defined in 49 CFR 173.421.
- Excepted packages of instruments and articles—instruments and articles with individual activities and total package activities that do not exceed the limits in 49 CFR 173.425 and that meet additional criteria defined in 49 CFR 173.424.
- Type-A quantity—an amount of activity per package that does not exceed the “A” value for that material.
- Type-B quantity—an amount of activity per package that exceeds the “A” value for that material.
- HRCQ—an amount of activity per package that is greater than either 1000 TBq or 3000 times its “A” value.

Self-Assessment

1. List the two forms of radioactive material and define them.

   a.

   b.

2. Define the following:

   a. A_1

   b. A_2

   c. HRCQ

3. Complete the following table by placing the appropriate information in the column that identifies the activity classification for the given isotope (all are in normal form). Then select the correct classification (HINT: More than one may apply).

Radionuclide	Amount	A_2	Type A	Type B	HRCQ
^{241}Am	1.259 GBq				
^{14}C	1.97 TBq				
^{60}Co	703 TBq				
^{137}Cs	0.14 TBq				
^{239}Pu	0.26 TBq				
^{151}Sm	1591 TBq				
^{90}Sr	0.44 TBq				
T(H-3)	1036 TBq				

Self-Assessment—continued

4. Based on activity alone (consider 173.425 only), determine whether a limited quantity of normal-form material is present by completing the following table.

Radionuclide (Physical Form)	Amount (Bq)	Ltd Qty Maximum (Bq)	Ltd Qty	Not Ltd Qty
^{14}C solid	2.21 MBq			
^{60}Co solid	0.037 TBq			
^{131}I gas	14.8 GBq			
^{210}Po liquid solution	1.2 MBq			
^{239}Pu	200 nCi			

Answers to Activities

Activity 7: Determination of Values for A_1 and A_2

1. $A_1 = 2.0$ TBq
2. $A_2 = 6.0 \times 10^{-1}$ TBq = 0.6 TBq
3. $A_2 = 3.0 \times 10^{-3}$ TBq = 0.003 TBq
4. $A_1 = 4.0 \times 10^{1}$ TBq = 40 TBq

Activity 8: Determination of Type-A and Type-B Quantities

1. 5 TBq < $A_1 = 4.0 \times 10^{1}$ TBq = 40 TBq
   Type-A quantity
2. 1 TBq > $A_2 = 1 \times 10^{-3}$ TBq = 0.001 TBq
   Type-B quantity
3. 1 TBq = $A_2 = 1.0$ TBq
   Type-A quantity
4. 5 MBq = 0.000,005 TBq = 5×10^{-6} TBq
   5×10^{-6} TBq < A_2 = unlimited
   Type-A quantity
5. 5 GBq = 0.005 TBq = 5×10^{-3} TBq
   5×10^{-3} TBq > $A_2 = 1.0 \times 10^{-3}$ TBq
   Type-B quantity
6. 50,000 GBq = 50 TBq
   50 TBq/2 = 25 TBq < $A_2 = 30$ TBq
   Type-A quantity

Answers to Activities—continued

Activity 9: Determination of HRCQ

1. 54,000 Ci = 2000 TBq

   A_2 = 1 TBq

   (3000) (A_2) = (3000) (1 TBq) = 3000 TBq

   1000 TBq is <3000 TBq

   2000 TBq is >1000 TBq

   HRCQ

2. $A_2 = 1 \times 10^{-3}$ TBq = 0.001 TBq

   (3000)(A_2) = (3000) (1×10^{-3} TBq) = 3.0 TBq

   3 TBq is <1000 TBq

   5 TBq is >3 TBq

   HRCQ

3. $A_2 = 2.0 \times 10^{-1}$ TBq = 0.2 TBq

   (3000)(A_2) = (3000) (0.2 TBq) = 600 TBq

   600 TBq is <1000 TBq

   600 TBq = 600 TBq

   Not HRCQ

4. $A_2 = 4 \times 10^{-4}$ TBq

   (3000)(A_2) = (3000) (4×10^{-4} TBq) = 1.2 TBq

   1.2 TBq is <1000 TBq

   1 TBq is <1.2 TBq

   Not HRCQ

Activity 10: Determination of Limited Quantities

1. $A_2 = 4 \times 10^{-3}$ TBq

   (0.001)(A_2) = (0.001) (4×10^{-3} TBq) = 4×10^{-6} TBq = 4 MBq

   3.5 MBq $\leq$ 4 MBq

   Limited quantity

2. A_2 = 3.0 TBq

   (0.0001)(A_2) = (0.0001) (3.0 TBq) = 0.0003 TBq

   0.002 TBq > 0.0003 TBq

   Not a limited quantity

Answers to Self-Assessment

1. a. Special form—a single, solid piece that meets the test requirements of 49 CFR 173.469; essentially, special-form material does not pose a contamination threat.

   b. Normal form—anything that is not special form; normal-form material poses both a contamination and radiation concern.

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

   b. A_2 means the maximum activity of radioactive material, other than a special form of LSA material or SCOs, permitted in a Type-A package.

   c. HRCQ—a quantity within a single package that exceeds 3000 times the radionuclide's A_1 or A_2 value, as appropriate, or 1000 TBq (27,000 Ci), whichever is least.

3. Complete the following table by placing the appropriate information in the column that identifies the activity classification for the given isotope (all are in normal form). Then select the correct waste classification (HINT: More than one may apply.)

Radionuclide	Amount	A_2	Type A	Type B	HRCQ
^{241}Am	1.259 GBq	0.001TBq		X	
^{14}C	1.97 TBq	3 TBq	X		
^{60}Co	1211 TBq	0.4 TBq		X	X
^{137}Cs	0.14 TBq	0.6 TBq	X		
^{210}Po	62 TBq	0.02 TBq		X	
^{239}Pu	0.26 TBq	0.001 TBq		X	
^{90}Sr	0.44 TBq	0.3 TBq		X	
^{131}I	20000 Ci	0.7 TBq		X	X

4. Based on activity alone (consider 173.425 only), determine whether a limited quantity is present by completing the following table.

Radionuclide (Physical Form)	Amount (Bq)	LTD Qty Maximum (Bq)	LTD Qty	Not LTD Qty
^{14}C solid	2.21 MBq	0.0003 TBq	X	
^{60}Co solid	0.037 TBq	0.0004 TBq		X
^{131}I Gas	14.8 GBq	0.0007 TBq		X
^{210}Po liquid solution	1.2 MBq	0.00002 TBq	X	
^{239}Pu	200 nCi	0.0000001 TBq	X	

Notes . . .

Proper Shipping Names for Radioactive Material

Objective

Upon completing this module, you will be able to determine the appropriate radioactive material, hazard class, proper shipping name (PSN) for a given material (Objective 4).

Available Proper Shipping Names for Radioactive Material

The DOT recognizes 21 different PSNs for Class 7 (radioactive) material in the Hazardous Materials Table (HMT) (49 CFR 172.101). All but three of the PSNs for Class 7 follow the same format. The format starts with the words “Radioactive Materials.” After this, the PSN describes either the package (Type A, excepted package, etc.), or the type of radioactive material (LSA, uranium hexafluoride, etc.). Any additional words in italics that describe the material are not part of the PSN. The PSN is only the words in bold Roman type.

Three other PSNs do not follow the format explained above: (1) radioactive material, transported under special arrangements; (2) radioactive material, transported under special arrangements, fissile; and (3) uranium hexafluoride, radioactive material, excepted package.

The first and second of these three unusual PSNs can be used only by special arrangement under a DOT special permit. [49 CFR 172.102, provision 139].

Available Proper Shipping Names for Radioactive Material—continued

The following table provides a breakdown of the PSNs for radioactive material.

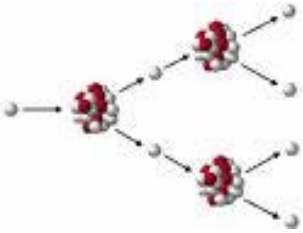
For . . .	the PSNs that apply are . . .	UN[a] #
uranium hexafluoride	• **Radioactive material, uranium hexafluoride, fissile;** and • **Radioactive material, uranium hexafluoride,** *nonfissile or fissile excepted.* • **Uranium hexafluoride, radioactive material, excepted package***, <0.1 kg per package,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

[a]UN = United Nations.

Uranium Hexafluoride Packaging and Transportation

Uranium hexafluoride (UF_6) packaging and transportation are regulated under both NRC and DOT requirements. The hazardous materials regulations contain provisions that govern many aspects of UF_6 packaging and shipment preparation. The NRC regulates fissile material and Type-B packaging designs for all material. Because UF_6 may be fissile material, the NRC may also regulate it. (49 CFR 173.420)

Fissile Material



The DOT defines fissile material as ^{239}Pu, ^{241}Pu, ^{233}U, ^{235}U, or any combination of these radionuclides (49 CFR 173.403). Authorized fissile material packages are discussed in 49 CFR 173.417 (Authorized fissile material packages). If any of the fissile isotopes are present in amounts greater than those listed in 49 CFR 173.453, they are considered to be fissile. If the isotopes are present in amounts less than those listed in 173.453, they are considered to be fissile-excepted.

Fissile material shipments are discussed in 49 CFR 173.453 (Fissile materials—exceptions), 173.457 (Transportation of fissile material packages—specific requirements), and 173.459 (Mixing of fissile material packages with nonfissile or fissile-excepted material packages).

Fissile material meeting the requirements of at least one of the 173.453 paragraphs a through f is excepted from the requirements for fissile material (except as noted) and 173.457 and 173.459. For example, the 49 CFR 173.453 paragraph b exception is for packages that contain no more than 15 g of fissile radionuclides, provided that the package has at least 200 g of solid nonfissile material for every gram of fissile material.

Radioactive Material Transported under Special Arrangement

Special arrangement means those provisions approved by the competent authority, under which consignments that do not satisfy all the applicable requirements may be transported.

Transported under special arrangement is clarified in 49 CFR 172.102, special provisions code 139. The term *associate administrator* means the associate administrator for hazardous materials safety (DOT), Research and Special Programs Administration (49 CFR 107.1).

Radioactive Material Transported under Special Arrangement—continued

The PSN "radioactive material, transported under special arrangement, fissile" is used for transportation of a package of fissile radioactive material that does not satisfy all of the applicable requirements. The PSN "radioactive material, transported under special arrangement, *nonfissile or fissile excepted,"* is used for transportation of a package of nonfissile or fissile-excepted radioactive material that does not satisfy all of the applicable requirements.

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

"Radioactive material, Type B(M) package" is used only when a nonfissile or fissile-excepted radioactive material (the activity of which exceeds a Type-A quantity) is being shipped.

"Radioactive material, Type B(M) package, fissile" is used only when a fissile radioactive material (the activity of which exceeds a Type-A quantity) is being shipped.

The letter "M" in a Type-B(M) package identifies multilateral approval (49 CFR 173.403, definition of "package"). Multilateral approval means approval of a package design or shipment by the relevant competent authority of the country of origin and each country through or into which the package or shipment is to be transported. This definition does not include approval from a country over which Class 7 (radioactive) material is carried in aircraft if no stop is scheduled in that country.

"Radioactive material, Type B(U) package" is used only when a nonfissile or fissile-excepted radioactive material (the activity of which exceeds a Type-A quantity) is being shipped.

"Radioactive material, Type B(U) package, fissile" is used only when a fissile radioactive material (the activity of which exceeds a Type-A quantity) is being shipped.

The letter "U" in a Type-B(U) package identifies unilateral approval (49 CFR 173.403, definition of "package"). Unilateral approval means a package design approved solely by the competent authority of the country of origin of the design.

Note: *The PSN "Radioactive material, Type B(U) package," UN2916 is also to be used for DOT specification Type-B and other pre-1967 government-approved packagings.*

Type-A Packages

"Radioactive material, Type A package," is used when the radioactive material (the activity of which is less than or equal to its A_2 value) is being shipped.

"Radioactive material, Type A package, special form, fissile" is used only when the radioactive material (the activity of which is less than or equal to its A_1 value) being shipped is a fissile material and meets the definition of special form.

"Radioactive material, Type A package, special form, *nonfissile or fissile excepted"* is used only when the radioactive material (the activity of which is less than or equal to its A_1 value) being shipped is not fissile or is fissile-excepted material and meets the definition of special form.

Before a proper shipping name that contains the words "special form" can be used, the shipper must have and maintain either a valid, government-approved, special-form certificate or the complete documentation that supports certification as special form [49 CFR 173.476(b)].

Excepted Package—Empty Packaging

"Radioactive material, excepted package—empty packaging" applies only to those Class 7 (radioactive) materials that meet the conditions in 49 CFR 173.428. All of the conditions indicated in that section, including those referenced, must be met for this proper shipping name to be associated with a Class 7 (radioactive) material. In particular, the packaging must be emptied of contents as far as practical.

If all of the conditions specified in 49 CFR 173.428 are met, including those referenced, then the proper shipping name "radioactive material, excepted package—empty packaging" may be used and the shipper is excepted from the following normal requirements:

- marking (except for the UN identification number marking requirement described in paragraph 173.422[a]),
- labeling (except for the specified "Empty" label), and
- shipping papers and certification.

Excepted Package—Empty Packaging—continued

If any one of the conditions specified in 49 CFR 173.428 is not met, then the proper shipping name “radioactive material, excepted package—empty packaging” is not authorized, and the exceptions associated with this proper shipping name are not available.

Excepted Package—Limited Quantity of Material

The requirements for a limited quantity of radioactive material are presented in 49 CFR 173.421 and 173.425. All of the requirements in these sections, including those referenced, must be met before a shipper may use the proper shipping name “radioactive material, excepted package—limited quantity of material.”

The following requirements are stipulated for limited quantities of Class 7 (radioactive) material in 49 CFR 173.421:

- Per paragraph 173.422(a), 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.
- The activity per package may not exceed the relevant limit specified in 49 CFR 173.425, Table 4.
- Each package must meet the general design requirements of 49 CFR 173.410.
- The radiation level at any point on the external surface of the package may not exceed 0.005 mSv/h (0.5 mrem/h).
- The nonfixed (removable) radioactive surface contamination on the external surface of the package may not exceed the limits specified in paragraph 49 CFR 173.443(a).
- The outside of the inner packaging or, if there is no inner packaging, the outside of the packaging itself bears the marking “Radioactive.”
- The package does not contain fissile material, unless excepted by 49 CFR 173.453.
- The material is otherwise packaged for shipment, as specified in 49 CFR 173.422.

If a shipper meets all the requirements stipulated in 49 CFR 173.421, then the shipper is excepted from the following, normal shipping requirements for Class 7 (radioactive) material:

- specification packaging,

Excepted Package—Limited Quantity of Material—continued

- marking (except for the UN identification number marking requirement described in paragraph 173.422[a]),
- labeling, and
- shipping papers and certification (if the material is not a hazardous substance or a hazardous waste).

If a shipper fails to comply with any one of the requirements for a limited quantity of Class 7 (radioactive) material, then the proper shipping name “radioactive material, excepted package—limited quantity of material” is not authorized and the exceptions associated with this proper shipping name are not available.

Excepted Package—Instruments or Articles

The requirements for excepted packages of instruments or articles are presented in 49 CFR 173.424 and 173.425. All of the requirements in these sections must be met before a shipper may use the proper shipping name “radioactive material, excepted package—instruments or articles.”

The following requirements are listed in 49 CFR 173.424 and are similar to those required for limited quantities:

- Each package must meet the general design requirements of 49 CFR 173.410
- The total activity per instrument or article may not exceed the relevant limit specified in 49 CFR 173.425, Table 4
- The total activity of the package may not exceed the relevant limit specified in 49 CFR 173.425, Table 4
- The radiation level at 10 cm (4 in.) from any point on the external surface of any unpackaged instrument or article does not exceed 0.1 mSv/h (10 mrem/h)
- The active material is completely enclosed by nonactive components (a device performing the sole function of containing radioactive material shall not be considered to be an instrument or manufactured article)
- The radiation level at any point on the external surface of the package bearing the instrument or article may not exceed 0.005 mSv/h (0.5 mrem/h) or, for exclusive-use domestic shipments, 0.02 mSv/h (2 mrem/h)

Excepted Package—Instruments or Articles—continued

- The nonfixed (removable) radioactive surface contamination on the external surface of the package may not exceed the limits specified in paragraph 49 CFR 173.443(a)
- Except as provided in 49 CFR 173.426, the package contains no more than 15 g of ^{235}U
- The package is otherwise prepared for shipment, as specified in 49 CFR 173.422

If all of the conditions specified in 49 CFR 173.424 are met, then the shipper is excepted from the following normal requirements for the transport of Class 7 (radioactive) material:

- specification packaging;
- marking, except for paragraph 173.422(a), which states that 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 HMT in 172.101;
- labeling; and
- shipping papers and certification (if the material is not a hazardous substance or a hazardous waste).

If any one of the conditions specified in 49 CFR 173.424 is not met, then the proper shipping name "radioactive material, excepted package—instruments or articles" is not authorized and the exceptions associated with this proper shipping name are not available.

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

"Radioactive material, excepted package—articles manufactured from natural *or* depleted uranium *or* natural thorium" applies only to articles in which the sole Class 7 (radioactive) material content is natural or unirradiated depleted uranium or natural thorium. The requirements for this exception are given in Section 173.426 and include

- Each package meeting the general design requirements of Section 173.410
- The outer surface of the uranium or thorium being enclosed in an inactive sheath made of metal or other durable protective material

Excepted Package—Articles Manufactured from Natural *or* Depleted Uranium *or* Thorium—continued

- The conditions specified in Sections 173.421 (a)(2), (3), and (4) are met—note; Section 173.421 does not contain a (2), (3,) or (4). However, Section 173.420, Uranium Hexafluoride, contains Sections (a)(2), (3), and (4); therefore, this issue may be a typo that has yet to be corrected by the DOT.
- The article is otherwise prepared for shipment in accordance with Section 173.422, Additional Requirements for Excepted Packages Containing Class 7 (Radioactive) Material.

If all of the requirements specified in 49 CFR 173.426 are met, the use of this proper shipping name is authorized and the shipper is excepted from the following requirements for the transport of Class 7 (radioactive) material:

- specification packaging;
- marking, except for paragraph 173.422(a), which states that 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; and
- shipping papers and certification (if the material is not a hazardous substance or a hazardous waste).

If the limited quantity also meets the definition of another hazard class, the shipper must also meet those requirements. The package must be classed for that additional hazard, packaged for that hazard, and properly shipped to meet the requirements of that hazard class.

If any one of the conditions specified in 49 CFR 173.426 is not met, then the proper shipping name "radioactive material, excepted package—articles manufactured from natural *or* depleted uranium *or* natural thorium" is not authorized and the exceptions associated with this proper shipping name are not available.

Low Specific Activity Material

As defined in 49 CFR 173.403, LSA material is Class 7 (radioactive) material with limited specific activity. To qualify as LSA, the radioactive material must satisfy one of the three sets of conditions included in the LSA definition. Each set of conditions defines a different group of LSA. The three LSA groups are referred to as LSA-I, LSA-II, and LSA-III. LSA-I is limited to the lowest specific activity. LSA-III allows the highest specific activity. The DOT defines the three LSA groups as follows:

- LSA-I
  - uranium and thorium ores, concentrates of uranium and thorium ores, and other ores containing naturally occurring radionuclides, which are intended to be processed for the use of these radionuclides; or
  - Natural uranium, depleted uranium, natural thorium, or their compounds or mixtures, provided they are unirradiated and in solid or liquid form; or
- Radioactive material for which the A2 value is unlimited; or other radioactive material in which the activity is distributed throughout and the estimated average specific activity does not exceed 30 times the values for activity concentration specified in §173.436, or calculated in accordance with §173.433, or 30 times the default values listed in Table 8 of §173.433.
- LSA-II
  - water with tritium concentration up to 0.8 TBq/L (20.0 Ci/L) or
  - other radioactive material in which the activity is distributed throughout and the average specific activity does not exceed 10^{-4} A_2/g for solids and gases and 10^{-5} A_2/g for liquids.
- LSA-III: Solids (e.g., consolidated wastes and activated material), excluding powders, that meet the requirements of 49 CFR 173.468 and in which
  - the Class 7 (radioactive) material is distributed throughout a solid or a collection of solid objects or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, or ceramic);
  - the Class 7 (radioactive) material is relatively insoluble or is intrinsically contained in a relatively insoluble material so that, even under loss of packaging, the loss of Class 7

Low Specific Activity Material—continued

(radioactive) material per package by leaching when placed in water for 7 days would not exceed 0.1 A_2; and

– the estimated average specific activity of the solid, excluding shielding material, does not exceed 2×10^{-3} A_2/g.

Additional requirements that must be met are set forth in 49 CFR 173.427 and include

- surface dose rate limits of 1 rem/h at 10 ft for the unshielded material,
- single conveyance quantity limits which are given in Table 5 of 49 CFR 173.427,
- fissile excepted per 173.453 if the material contains fissile radionuclides,
- contamination control limits detailed in Section 173.443,
- external radiation level limits detailed in Section 173.441, and
- requirements for LSA material to be consigned as exclusive-use.

Section 173.427 also provides packaging requirements for LSA material.

If the shipment of Class 7 (radioactive) material meets the definition of LSA and any additional requirements stipulated in 49 CFR 173.427, the use of this proper shipping name is authorized and exceptions to some DOT packaging and shipping requirements are available.

If the Class 7 (radioactive) material does not meet the definition of LSA or any of the additional requirements set forth in 49 CFR 173.427, then the use of this proper shipping name is not authorized and the exceptions associated with this proper shipping name are not available.

Surface-Contaminated Objects

As defined in 49 CFR 173.403, an SCO is a solid object that is not itself radioactive but that has Class 7 (radioactive) material distributed on any of its surfaces. The DOT defines two groups of SCO:

- SCO-I: A solid object on which
  – the non-fixed contamination on the accessible surface, averaged over 300 cm^2 (or the area of the surface if

Surface-Contaminated Objects—continued

<300 cm^2), does not exceed 4 Bq/cm^2 (10^{-4} microCi/cm^2) for beta and gamma and low-toxicity alpha emitters, or 0.4 Bq/cm^2 (10^{-5} microCi/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 4×10^4 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters, or 4×10^3 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 4×10^4 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters or 4×10^3 Bq/cm^2 for all other alpha emitters.

- 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 (10^{-2} µCi/cm^2) for beta and gamma and low-toxicity alpha emitters or 40 Bq/cm^2 (10^{-3} µCi/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.

The use of this proper shipping name is authorized only if the Class 7 (radioactive) material meets the requirements of one of the two SCO classes. Additional requirements are stipulated in 49 CFR 173.427.

If the shipment of Class 7 (radioactive) material meets the definition of SCO and any additional requirements stipulated in 49 CFR 173.427, the use of this proper shipping name is authorized and exceptions to some DOT packaging and shipping requirements are available.

If the Class 7 (radioactive) material does not meet the definition of SCO or any of the additional requirements set forth in 49 CFR 173.427, then the use of this proper shipping name is not authorized and the exceptions associated with this proper shipping name are not available.

Self-Assessment

1. How many DOT proper shipping names are available for Class 7 material?

2. Identify the proper shipping names for materials with these characteristics:

   a.
   - Class 7 (radioactive) material
   - material activity less than or equal to A_1
   - Type-A package
   - special-form material
   - nonfissile material (not ^{239}Pu, ^{241}Pu, ^{233}U, or ^{235}U)

   b.
   - Class 7 (radioactive) material
   - material activity is greater than A_2
   - Type B(M) package—multilateral approval
   - fissile material (is ^{239}Pu, ^{241}Pu, ^{233}U, or ^{235}U)
   - may or may not be special-form material
   - not fissile-excepted material

   c.
   - Class 7 (radioactive) material
   - material activity less than or equal to limited quantity per package value in 173.425
   - excepted package per 173.421
   - meets general design requirements of 173.410
   - satisfies 173.422
   - nonfissile material (not ^{239}Pu, ^{241}Pu, ^{233}U, or ^{235}U)
   - fissile-excepted material
   - less than or equal to 2 g of ^{235}U
   - package surface dose rate ≤0.5 mrem/h
   - satisfies UN marking of 173.422

   d.
   - Class 7 (radioactive) material
   - material activity less than or equal to limits for instrument or article and for package value in 173.425
   - excepted package per 173.424
   - meets general design requirements of 173.410
   - fissile-excepted material (≤2 g of ^{235}U)
   - dose rate at 10 cm from article or instrument ≤10 mrem/h
   - active material completely enclosed
   - satisfies UN marking of 173.422

Self-Assessment—continued

e.
- Class 7 (radioactive) material—articles manufactured from natural *or* depleted uranium *or* natural thorium
- meets general design requirements of 173.410
- excepted package per 173.426
- satisfies UN marking of 173.422
- nonfissile material (not ^{239}Pu, ^{241}Pu, ^{233}U, or ^{235}U)
- fissile-excepted material
- dose rate at package surface ≤0.5 mrem/h

f.
- previously contained Class 7 (radioactive) material
- meets general design requirements of 173.410
- excepted package per 173.428
- satisfies UN marking of 173.422
- nonfissile material (not ^{239}Pu, ^{241}Pu, ^{233}U, or ^{235}U)
- fissile-excepted material
- internal smears less than or equal to 100 times limits is 173.443

g.
- Class 7 (radioactive) LSA-I material per 173.403
- package per 173.427
- not special-form material
- nonfissile material (not ^{239}Pu, ^{241}Pu, ^{233}U, or ^{235}U)
- fissile-excepted material

h.
- Class 7 (radioactive) SCO-I material per 173.403
- package per 173.427
- not special-form material
- nonfissile material (not ^{239}Pu, ^{241}Pu, ^{233}U, or ^{235}U)
- fissile-excepted material

3. Based on activity alone, identify the appropriate proper shipping name and UN number for the following radioactive materials. Assume you have access to approved Type-A and Type-B(M) packagings.

   a. 9.25 TBq (200 Ci) ^{193}Au, shipped under unilateral agreement

   b. 0.0074 TBq (199 mCi), ^{239}Pu, solid

   c. 0.0156 GBq (0.422 mCi), ^{226}Ra solid

   d. 15,600 GBq (421.6 Ci), ^{40}K solid

   e. 0.3 TBq (8.1 Ci), ^{90}Sr, special form

Self-Assessment—continued

f. 0.5 TBq (13.5 Ci), ^{90}Sr, special form, shipped under multilateral agreement

Answers to Self-Assessment

1. How many DOT proper shipping names are available for Class 7 material?

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2. Identify the proper shipping names for materials with these characteristics:

   a. Radioactive material, Type-A package, special form, *nonfissile or fissile excepted*

   b. Radioactive material, Type-B(M) fissile

   c. Radioactive material, excepted package—limited quantity of material

   d. Radioactive material, excepted package—instruments *or* articles

   e. Radioactive material, excepted package—articles manufactured from natural *or* depleted uranium *or* natural thorium

   f. Radioactive material, excepted package—empty packaging

   g. Radioactive material, low specific activity (LSA-I) *nonfissile or fissile excepted*

   h. Radioactive material, surface contaminated object (SCO-I) *nonfissile or fissile excepted*

3. Based on the activity alone, identify the appropriate proper shipping name and UN number for the following radioactive materials.

   a. 9.25 TBq (200 Ci) ^{193}Au, shipped under unilateral agreement

      Radioactive material, Type-B(U) package, UN2916

   b. 0.0074 TBq (0.995 mCi), ^{239}Pu, solid

      Radioactive material, Type-A package, Fissile UN3327

   c. 9.25 MBq (0.25 mCi), ^{39}Ar gas

      Radioactive material, excepted package—limited quantity of material, UN 2910

   d. 222 GBq (6 Ci), ^{40}K solid

      Radioactive material, Type-A package UN2915

Answers to Self-Assessment—continued

e. 0.3 TBq (8.1 Ci), ^{90}Sr, special form

   Radioactive material, Type-A package, special form, UN3332

f. 0.5 TBq (13.5 Ci), ^{90}Sr, special form, shipped under multilateral agreement

   Radioactive material, Type-B(M) package, UN2917

Requirements for Hazardous Substances

Module Objective

Upon completing this module, you will be able to determine when a single radionuclide meets the DOT definition of a hazardous substance (Objective 5).

Requirements for Defining a Hazardous Substance

Appendix A of 49 CFR 172.101 lists materials and their corresponding reportable quantities (RQs) that are listed or designated as hazardous substances under Section 101(4) of the Comprehensive Environmental Response, Compensation, and Liability Act. Appendix A is divided into two tables. RQs of hazardous substances other than radionuclides are listed in Table 1 of Appendix A. RQs for radionuclides are listed in Table 2 of Appendix A.

A material listed in Appendix A is regulated as a hazardous material and as a hazardous substance under 49 CFR 171–180 if it meets the definition of a hazardous substance in 49 CFR 171.8. This definition stipulates that a hazardous substance is a material, including its mixtures and solutions, that

- is listed in Appendix A to 49 CFR 172.101;
- is in a quantity, in one package, that equals or exceeds the RQ listed in Appendix A to 49 CFR 172.101; and
- if it is a radionuclide in a mixture or solution, conforms to paragraph 7 of Appendix A of 49 CFR 172.101.

Paragraph 6 of Appendix A to 49 CFR 172.101 stipulates that if a material is listed in both Table 1 and Table 2 of Appendix A, the lower RQ shall apply.

The requirements stipulated in paragraph 7 of Appendix A to 49 CFR 172.101 must also be met. This paragraph sets forth the requirements for determining whether a given quantity of a radionuclide mixture, contained in a single package, constitutes an RQ.

RQs for radioactive mixtures are covered in more detail in *HMPT: Advanced Radioactive Material Transportation Live*.

Determination of RQ Values for Single, Known Radionuclides

Table 2 in Appendix A of 49 CFR 172.101 is used to determine whether a radioactive material qualifies as a hazardous substance. Radionuclides are listed in alphabetical order in column 1. The RQ for each listed radionuclide is provided in column 3. The RQs are expressed in curies, followed, in parentheses, by the equivalent activity expressed in terabecquerels. To determine the RQ for a listed radionuclide, find the radionuclide in Table 2 and then find the corresponding activity in the third column of Table 2. To qualify as a hazardous substance, the amount of activity in a single package must be equal to or greater than the RQ value listed in Table 2.

Many important requirements can be found in the footnotes at the end of Table 2. The following requirements are of particular significance:

- 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. For example, the Table 1 RQ for uranyl acetate and uranyl nitrate is 100 lb, and the Table 2 RQ for ^{238}U is 0.0037 TBQ (~680 lb). Therefore, each compound becomes a reportable quantity when the mass is ≥100 lb.

Activity 11: Determination of RQ Values for Single, Known Radionuclides (Answers on page 82)

Indicate which of the following activities constitute(s) an RQ.

1. 22 TBq of ^{133}Te packaged in a single package.

2. 22 TBq of ^{132}Te packaged in a single package.

3. 3.7 TBq of ^{201}Pb in special form and packaged in a single package.

4. 3.7 TBq of ^{59}Ni divided equally between two packages.

Self-Assessment

1. What is an RQ value?

2. For what are RQs used?

2. Identify whether the following radionuclides meet the definition of a hazardous substance.

Radionuclide	Amount (Bq)	RQ	Not RQ
^{137}Cs	3.7 MBq		
^{60}Co	15.9 Ci		
^{103}Pd	370 GBq		
^{106}Ru	3.7 TBq		
^{99}Tc	34.4 Ci		
^{238}U	200 Ci		

3. What is the “default” RQ value for an unknown or unlisted radionuclide?

Answers to Activity

Activity 11: Determination of RQ Values for Single, Known Radionuclides

1. RQ = 37 TBq
   22 TBq is less than the RQ (37 TBq).
   Not reportable quantity
2. RQ = 0.37 TBq
   22 TBq is greater than the RQ (0.37 TBq).
   Reportable quantity
3. RQ = 3.7 TBq
   3.7 TBq is equal to the RQ (3.7 TBq).
   Reportable quantity
4. RQ = 3.7 TBq
   One half of 3.7 TBq is less than the RQ (3.7 TBq).
   Not reportable quantity

Answers to Self-Assessment

1. What is an RQ value?

   Reportable quantity (RQ) (for the purposes of subchapter C) means the quantity specified in column 2 of the appendix to §172.101 for any material identified in column 1 of the appendix. For radionuclides, the RQ values are given in Table 2.

2. For what are RQs used?

   The RQ value is compared with the activity of a radionuclide in a package to determine whether the radionuclide is a hazardous substance.

Radionuclide	Amount (Bq)	RQ	Not RQ
^{137}Cs	3.7 MBq		X
^{60}Co	15.9 Ci	X	
^{103}Pd	370 GBq		X
^{106}Ru	3.7 TBq	X	
^{99}Tc	34.4 Ci	X	
^{238}U	200 Ci	X	

3. What is the “default” RQ value for an unknown or unlisted radionuclide?

   The default RQ value for an unknown or unlisted radionuclide is 0.037 TBq (1 Ci).

Notes . . .

Packaging Requirements for Radioactive Material

Module Objective

Upon completing this module, you will be able to determine the appropriate packaging required for a given radioactive material (Objective 6).

General Packaging Requirements

The four levels of nonbulk packagings for radioactive material, from most to least stringent requirements, are

- Type-B packagings,
- Type-A packagings,
- industrial packagings, and
- excepted packagings.

The DOT has established a minimum set of requirements for all types of packagings used in the transport of Class 7 (radioactive) material. These minimal requirements are provided in 49 CFR 173.410.

Section 173.410 requires that all packagings used to transport Class 7 (radioactive) material meet the requirements of

- Subpart A of Part 173,
- Subpart B of Part 173, and
- Section 173.410.

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General Packaging Requirements—continued

The relevant section of Part 173 Subpart A is 173.3, which requires that

- the packaging used for the transportation of hazardous materials conform to the requirements of 49 CFR 173 and
- the methods of manufacture, packing, and storage be open to inspection.

The regulations setting forth packaging requirements for a specific hazardous material apply to all modes of transportation unless otherwise stated or unless exceptions from packaging requirements are authorized.

The Subpart B requirements, which are the same for all hazardous materials, are found in Sections 173.21, 173.24, and 173.24(a). Section 173.24 addresses

- package integrity,
- packaging authorization,
- packaging compatibility, and
- general performance and durability requirements.

Section 173.24(a) prescribes further requirements for nonbulk packagings. Of particular note are the following:

- a packaging is authorized for a hazardous material only if the packaging is prescribed or permitted for the hazardous material in a packaging section specified for that material in column 8 of the 49 CFR 172.101 HMT;
- the person offering a hazardous material for transportation is responsible for ensuring that the packagings used and the hazardous material contained within are compatible;
- closures must be secure and leakproof; and
- the package will be capable of withstanding the effects of any acceleration, vibration, or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices or on the packaging integrity as a whole.

General Packaging Requirements—continued

Section 173.410 stipulates requirements that apply specifically to packages used for the shipment of Class 7 (radioactive) material. Each package must be designed so that

- the package can be easily handled and properly secured in or on a conveyance during transport;
- each lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner and so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of Subpart I of Part 173;
- the external surface, as far as practicable, will be free from protruding features and will be easily decontaminated;
- the outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect;
- each feature that is added to the package will not reduce the safety of the package;
- The package will be capable of withstanding the effects of any acceleration, vibration, or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices, even after repeated use (see §§173.24, 173.24a, and 173.24b);
- the materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and with the package contents (the behavior of the packaging and the package contents under irradiation will be taken into account); and
- all valves through which the package contents could escape will be protected against unauthorized operation.

General Packaging Requirements—continued

Additional requirements prescribed in 49 CFR 173.410 may apply, particularly to air shipments or shipments of liquids.

The DOT has also established external exposure rate limits for packages containing Class 7 (radioactive) material (49 CFR 173.441). Except for packages shipped by exclusive-use shipment, each package of Class 7 (radioactive) material offered for transportation must be designed and prepared for shipment so that under conditions normally incident to transportation

- the radiation level does not exceed 2 mSv/h (200 mrem/h) at any point on the external surface of the package and
- the TI—transport index—does not exceed 10 [49 CFR 173.441(a)].

Under specified conditions, a package that exceeds these radiation limits may be shipped by exclusive-use shipment [49 CFR 173.441(b)]. Packages shipped as exclusive use may have radiation levels up to 10 mSv/h (1000 mrem/h) on the package surface if the following conditions are met:

- The transport vehicle is closed;
- The package is secured so it cannot shift within the vehicle during transportation; and
- Nothing in the vehicle is loaded or unloaded during the shipment, except when the material is initially loaded and is finally unloaded.

Packages of Class 7 (radioactive) material must also meet

- thermal limits (49 CFR 173.442) and
- contamination limits (49 CFR 173.443).

Of the four package categories that the DOT authorizes for the shipment, industrial packagings are used primarily during the transport of LSA material and SCOs. These categories will be discussed further in *HMPT: Advanced Radioactive Material Transportation Live*. The requirements and uses of the three other types of packagings are discussed below.

Excepted Packages (Nonbulk)

To be acceptable for the shipment of Class 7 (radioactive) material, excepted packages must meet the minimum packaging standards prescribed in 49 CFR 173.410. Excepted packages are acceptable in the following situations:

- 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; and
- empty packagings.

The use of excepted packagings is allowed only when they are authorized in column 8A in the HMT (49 CFR 172.101).

Excepted packages must meet any additional requirements associated with individual proper shipping names. These requirements may include

- activity limits,
- external dose rate limits,
- contamination limits, and/or
- UN number markings.

Excepted packages are not required to have packaging identification codes marked on the packages. These requirements will be discussed in detail later in this course.

Industrial Packages

The requirements for industrial packages are established in 49 CFR 173.411. The three types of industrial packages are IP-1, IP-2, and IP-3. The requirements become more restrictive as you progress from IP-1 to IP-2 to IP-3. All packages must meet the 49 CFR 173.410 requirements discussed on page 88. The IP-1 packages have no further requirements.

IP-2 packages must meet 49 CFR 173.465 (c) and (d) requirements: a drop test and a stacking test. The package must pass these tests without loss or dispersal of the radioactive contents or without a significant increase of the surface radiation levels.

IP-3 packages must meet the IP-1 and IP-2 requirements, as well as the requirements of 49 CFR 173.412(a) through (j). These encompass most of the requirements for Type-A packages. Again, the package must pass these tests without loss or dispersal of the radioactive contents or without a significant increase of the surface radiation levels.

Type-A Packagings

Type-A packages are performance-tested packages that must meet those test conditions that simulate normal handling situations that could occur during actual transportation activities. Type-A packages are associated primarily with the following shipping situations:

- fissile material;
- limited quantities of material;
- special-form material;
- LSA material (nonexclusive use or greater than Type-A quantities);
- SCOs (nonexclusive use or greater than Type-A quantities); and
- specifically listed radioactive material proper shipping names.

With the exception of LSA material and SCOs, the maximum activity per Type-A package may not exceed Type-A quantities. Nonbulk Type-A packages are allowed only when they are authorized per column 8B in the HMT in 49 CFR 172.101.

General Requirements for Type-A Packagings

As with all nonbulk packages, Type-A packages must meet the general requirements of Part 173, Subparts A and B. Type-A packages must also meet the minimum requirements for packages used to transport Class 7 (radioactive) material as specified in 49 CFR 173.410.

Type-A Packagings—continued

Additional design requirements for Type-A packages are provided in 49 CFR 173.412. This section requires that Type-A packages be designed so that

- the outside of the package incorporates a feature, such as a seal, that while intact, indicates that the package has not been opened (this requirement may be met during shipment of multiple packages in closed transport vehicles in exclusive-use shipments by a seal on the cargo container);
- the minimum external dimension is not less than 10 cm;
- the containment and shielding are maintained during transportation in a temperature range between −40°C and 70°C;
- the packaging includes a containment system that can be securely closed with a positive fastening device;
- the effect of radiolytic decomposition on packaging components is taken into account;
- the containment system will not release its radioactive contents under the conditions of ambient pressure reduction specified;
- each valve, other than a pressure relief device, is provided with an enclosure to retain any leakage;
- any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;
- failure of any tie-down attachment that is a structural part of the packaging must not impair the ability of the packaging to meet other requirements of Part 173 Subpart I; and
- when evaluated against the performance requirements of Section 173.412 and the tests specified in Section 173.465 or using any of the methods authorized by Section 173.461(a), the packaging will prevent a
  - loss or dispersal of the radioactive contents and
  - significant increase in the radiation levels recorded or calculated at the external surfaces before the test.

Type-A packages containing liquids or gases must meet additional requirements.

Type-A Packagings—continued

Performance Requirements for Type-A Packagings

Type-A packaging must be capable of meeting certain performance requirements when evaluated against the tests specified in 49 CFR 173.465 or other methods as authorized in 173.461. These tests are designed to simulate conditions that might reasonably be encountered during the transportation of material contained in Type-A packaging. In particular, Type-A packaging must be capable of withstanding the following four tests:

- water spray,
- free drop,
- stacking, and
- penetration.

One prototype may be used for all tests if the requirements of the water spray test are met first. If the packagings are designed to contain liquids or gases, more stringent drop and penetration tests, as specified in 49 CFR 173.466, are required.

Shipping Requirements for Type-A Packages

Type-A packages are also subject to many additional requirements. These requirements (and the sections stipulating these additional requirements) include

- activity limits (49 CFR 173.431),
- radiation level limitations (49 CFR 173.441),
- thermal limitations (49 CFR 173.442), and
- contamination limits (49 CFR 173.443).

Type-A Packagings—continued

Authorized Type-A Packages

49 CFR 173.415 describes packages that are authorized for shipment if they do not contain quantities of Class 7 (radioactive) material exceeding the A_1 or A_2 level, as appropriate. These packages include

- DOT Specification 7A, Type-A general packaging (49 CFR 178.350);
- Type-A packaging that also meets the applicable standards for fissile material in 10 CFR 71 and that are used in accordance with 49 CFR 173.471;
- Type-B packages; and
- Type-A foreign-made packages.

Fissile material packages must be authorized under 49 CFR 173.417.

Caution: *Check with the Laboratory packaging engineer before using the DOT-7A packaging manual.*

To assist in identifying Type-A packages, the DOE has made available to all DOE employees and DOE contractors a DOT-7A packaging manual.

This manual is referred to as the “DOT-7A Blue Book” and identifies packagings that are or can be approved as DOT-7A packagings. An online copy of the manual can be found at https://rampac.energy.gov/docs/default-source/default-document-library/doe_rl-96-57-vol-1-v1.pdf?sfvrsn=2

Type-B Packagings

As with Type-A packages, Type-B, -B(U), and -B(M) (e.g., Type-B) packages are performance-tested packages. However, Type-B packages are designed to contain greater amounts of radioactive material, and the tests that they must pass are more rigorous than those required for Type-A packages. Whereas Type-A packages must withstand tests designed to simulate events that may occur during normal handling, Type-B packages must meet test conditions that simulate accident situations that may occur during transportation. Type-B packages are associated primarily with the following Class 7 (radioactive), Type-B material shipping situations:

- fissile material;
- fissile material, excepted quantities;
- special-form material; and
- “specifically listed” radioactive material proper shipping names.

Type-B packages may also be required for LSA material under some situations. Nonbulk, Type-B packages are allowed only when authorized in column 8B of the HMT (49 CFR 171.101).

General Requirements for Type-B Packages

As with all nonbulk packages, Type-B packages must conform to the requirements of

- Subpart A of Part 173,
- Subpart B of Part 173, and
- Section 173.410.

Type-B packages must also meet the requirements in 49 CFR 173.413, which stipulates that each Type-B(U) or Type-B(M) package must be designed and constructed to meet the applicable requirements in 10 CFR 71 (except as provided in 49 CFR 173.416).

Section 173.416 indicates the packages authorized for the shipment of Class 7 (radioactive) material in quantities exceeding A_1 or A_2 levels and the conditions under which a given packaging may be used.

Type B Packagings—continued

Performance Requirements for Type-B Packages

Section 173.467 prescribes the performance-testing requirements for Type-B packages. All Type-B packaging must meet the requirements prescribed in 10 CFR 71 for testing the ability of the packaging to withstand accident conditions that might be encountered during transportation. The following four tests are required:

- mechanical (drop and crush),
- puncture,
- fire, and
- immersion.

Offerers of a Type-B, Type-B(U) or Type-B(M) package that has been approved by the NRC under 10 CFR 71 must also comply with 49 CFR 173.471. To meet these requirements,

- the offer must be appropriately registered with the NRC,
- the outside of each package must be durably and legibly marked with an approved package identification marking, and
- each shipping paper associated with the shipment of the package must bear the approved package identification marking.

Export shipments must meet additional requirements stipulated in 49 CFR 173.471.

Type-B Packagings—continued

Shipping Requirements for Type-B Packages

Once assembled, Type-B packages must meet many additional requirements, including

- activity limits (49 CFR 173.431),
- radiation-level limitations (49 CFR 173.441),
- thermal limitations (49 CFR 173.442), and
- contamination limits (49 CFR 173.443).

Packages authorized for shipments of Class 7 (radioactive) material exceeding A_1 or A_2 levels, and the conditions under which that packaging may be used, are indicated in 49 CFR 173.416. The DOE is empowered to certify Type-B packages, as long as the requirements stipulated by the NRC for Type-B packages are met (49 CFR 173.7[d]). The DOE provides reference tools to assist DOE employees and DOE contractors in locating and assessing Type-B packagings.

Note: *B(U) refers to the need for unilateral approval of international shipments. B(M) refers to the need for multilateral approval of international shipments.*

Note: *DOT specification (e.g., DOT-6M) and pre-1967 Type-B packagings (identified as Type B) are authorized for domestic transportation only.*

Self-Assessment

1. List the four packaging types applicable to radioactive material.

2. Type-A packages may be used for what types of Class 7 material?
   a.
   b.
   c.
   d.
   e. .

3. What is the maximum contact dose rate for any Class 7 package that is shipped as nonexclusive use?

4. What is the maximum contact dose rate for any Class 7 package that is shipped as exclusive use?

5. Complete the following table to determine the appropriate packaging, based on activity alone, for the following radioactive material shipped under unilateral agreement.

Radionuclide	Amount	Packaging Type Required
Fiestaware	Two plates	
^{239}Pu (solid)	3.7 GBq	
^{14}C	0.002 TBq	
^{60}Co	10 Ci	
^{232}Th	1000 Ci	
^{65}Zn	56 Ci	

Answers to Self-Assessment

1. List the four packaging types applicable to radioactive material.

   a. Type B

   b. Type A

   c. Industrial

   d. Excepted

2. Type-A packages may be used for what types of Class 7 material?

   a. Fissile, including excepted fissile

   b. Special-form material

   c. LSA

   d. SCO

   e. Specifically listed radioactive material proper shipping names.

3. What is the maximum contact dose rate for any Class 7 package that is shipped as nonexclusive use?

   200 mrem/h

4. What is the maximum contact dose rate for any Class 7 package that is shipped as exclusive use?

   1000 mrem/h

5. Complete the following table to determine the appropriate packaging, based on activity alone, for the following radioactive material shipped under unilateral agreement.

Radionuclide	Amount	Packaging Type Required
Fiestaware	Two plates	Excepted
^{239}Pu (solid)	3.7 GBq	Type B(U)
^{14}C	0.002 TBq	Excepted
^{60}Co	10 Ci	Type A
^{232}Th	1 nCi	Excepted
^{65}Zn	56 Ci	Type B(U)

Marking Requirements for Radioactive Material

Module Objective

Upon completing this module, you will be able to identify the markings to be placed on a package of radioactive material (Objective 7).

General Marking Requirements

Unless specifically excepted, all packages of Class 7 (radioactive) material must be marked with specific information. General marking requirements are provided in Subpart D of Part 172.

Unless excepted, packages containing Class 7 (radioactive) material must have the same basic markings that are required for packages containing other hazardous materials. These basic markings are stipulated in 49 CFR 172.301 and include

- a proper shipping name,
- the corresponding UN identification number for radioactive material, and
- the name and address of the shipper and/or the receiver.

Specific Marking Requirements

Additional marking requirements that are unique to packages of Class 7 (radioactive) material are provided in 49 CFR 172.310 and are as follows:

- Each package with a gross mass >50 kg (110 lb.) must have its gross mass, including the unit of measurement (which may be abbreviated), marked on the outside of the package.
- Each industrial, Type-A, Type-B(U), or Type-B(M) package must marked with the words “Type IP-1,” “Type IP-2,” “Type IP-3,” “Type A,” “Type B(U),” or “Type B(M).”

Specific Marking Requirements—continued

- Each package that conforms to a "Type IP-1," "Type IP-2," "Type IP-3," or "Type A" package design must be marked on the outside of the package with the international vehicle registration code of the country of origin of the design. The international vehicle registration code for packages designed by a US company or agency is the symbol "USA."
- Type-B(U) and Type-B(M) packagings must be marked on the outside of the package with a radiation symbol that conforms to the requirements of Appendix B, Part 172.
- Each Type-B(U) and Type-B(M) fissile material package destined for export shipment must be marked "USA" in conjunction with the specification marking or other package certificate identification.

When required, "Type IP-1," "Type IP-2," "Type IP-3," "TYPE A," "TYPE B(U)," or "Type B(M)" must be marked in letters at least ½ in. high.

Specification 7A packaging must also be marked on the outside with the words "USA DOT-7A Type A" [49 CFR 178.350(b)].

Additional Marking Requirements

Other hazardous material markings may be necessary as required by the packaging contents. The following are examples of such markings:

- orientation markings placed on two opposite vertical sides of the package, with the arrows pointing in the correct upright direction (49 CFR 172.312),
- "inhalation hazard" or "POISON" (49 CFR 172.313), and
- the letters "RQ" if the substance is hazardous (49 CFR 172.324[b]).

Special marking requirements may apply to the following:

- excepted packages (49 CFR 173.421[d]) and
- packages containing
  - radioactive waste (40 CFR 262.32),
  - LSA material (49 CFR 173.427[a][6][vi]), and
  - SCO (49 CFR 173.427[a][6][vi]).

Additional Marking Requirements—continued

Except for radioactive material in packages labeled in accordance with 49 CFR 172.403, if the proper shipping name does not identify the hazardous substance by name, the name of the hazardous substance as shown in Appendix A to 49 CFR 172.101 shall be marked on the package, in parentheses, in association with the proper shipping name (49 CFR 172.324[a]). Alternate provisions are supplied for hazardous substances that are wastes.

Marking Specifications

When markings are placed on a package, they must meet the requirements stipulated in 49 CFR 172.304. Markings must be

- 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; and
- located away from any other marking that could substantially reduce its effectiveness.

Exceptions from Marking Requirements

Under some special conditions, packages containing Class 7 (radioactive) material are excepted from general marking requirements per 49 CFR 172, Subpart D. These special conditions include the following:

- limited quantities meeting the requirements of 49 CFR 173.421 (special markings are required),
- instruments and articles meeting the requirements of 49 CFR 173.424,
- manufactured articles containing only natural or depleted uranium or natural thorium meeting the requirements of 49 CFR 173.426,
- LSA material and SCO when shipped domestically under exclusive use as prescribed in 49 CFR 173.427 (special markings are required), and
- empty radioactive material packaging meeting the requirements of 49 CFR 173.428.

Packages subject to 173.422 are excepted from marking 172 Subpart D requirements; however, these packages are required to display the four-digit UN identification number preceded by the letters “UN” marked on the outside of each package.

Self-Assessment

1. It is required to mark the weight of the package if the package exceeds what weight?
2. For package types IP-1, IP-2 and IP-3, or Type A, what additional marking is required?
3. For packages that are Type B(U) and Type B(M), what additional symbols are needed?
4. When marking package types, what is the minimum height of the letters?
5. When are Class 7 packages excepted from some marking requirements?
6. Given the following information about a Class 7 package, how should it be marked?

   Weight is 37 kg, packaging is Type A, the country of origin of design is the United States, and the destination is within the USA. The package contains 10 Ci of ^{60}Co.

Answers to Self-Assessment

1. It is required to mark the weight of the package if the package exceeds what weight?

   110 lb (50 kg)

2. For package types IP-1, IP-2 and IP-3, or Type A, what additional marking is required?

   The package design must be marked on the outside of the package with the international vehicle registration code of the country of origin of the design. The international vehicle registration code for packages designed by a US company or agency is “USA.”

3. For packages that are Type B(U) and Type B(M), what additional symbols are needed?

   Type B(U) and Type B(M) packagings must be marked on the outside of the package with a radiation symbol that conforms to the requirements of Appendix B of Part 172.

4. When marking package types, what is the minimum height of the letters?

   ½ in.

5. When are Class 7 packages exempted from marking requirements?

   a. limited quantities meeting the requirements of 49 CFR 173.421 (special markings are required),

   b. instruments and articles meeting the requirements of 49 CFR 173.424,

   c. manufactured articles containing only natural or depleted uranium or natural thorium and meeting the requirements of 49 CFR 173.426,

   d. LSA material and SCO when shipped domestically under exclusive use as prescribed in 49 CFR 173.427 (special markings are required), and

   e. empty radioactive material packaging meeting the requirements of 49 CFR 173.428.

6. Given the following information about a Class 7 package, how should it be marked?

   Weight is 37 kg, packaging is Type A, the country of origin of design is the United States, and the destination is within the USA. The package contains 10Ci of ^{60}Co.

   RQ UN2915, Radioactive Material, Type A package, USA

Labeling Requirements for Radioactive Material

Module Objectives

Upon completing this module, you will be able to

- determine the label(s) to apply to a given radioactive material package (Objective 8),
- identify the entry requirements for radioactive material label(s) (Objective 9), and
- determine the proper placement for radioactive material label(s) (Objective 10).

General Labeling Requirements

Subpart E of Part 172 prescribes general labeling requirements for packages containing hazardous materials. Unless specifically excepted by regulations, all packages containing Class 7 (radioactive) material must be labeled as prescribed in Subpart E. The Subpart E general labeling requirements begin in 49 CFR 172.400. In particular, the DOT requires each person who offers for transportation a hazardous material in a nonbulk package or overpack to label the package or overpack with labels specified for the material in the 49 CFR 172.101 HMT and in Subpart E of Part 172. Some general exceptions are permitted in 49 CFR 172.400(a).

Specific labeling requirements for packages containing Class 7 (radioactive) material are stipulated in 49 CFR 172.403. Unless excepted by DOT regulations, each package of radioactive material must be labeled as specified in this section. Five labels are specifically associated with the shipment of radioactive material or empty packages that have contained radioactive material. These five labels are

- 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—continued

Of the three RADIOACTIVE labels, the RADIOACTIVE WHITE-I label indicates the least hazard. The RADIOACTIVE YELLOW-III label indicates the greatest hazard. The proper label to be affixed to a package of Class 7 (radioactive) material is based on the radiation level at the surface of the package and the dose rate at 1 meter, known as the transport index (TI).

The FISSILE label is an additional label and is required on packages with a FISSILE proper shipping name. Two FISSILE labels are required for each fissile package. The FISSILE label is covered in m detail in *HMPT: Advanced Radioactive Material Transportation Live*.

The TI is a dimensionless number (rounded up to the next tenth) that is placed on the label of a package to indicate the degree of control to be exercised by the carrier during transport. To determine the TI, multiply the maximum radiation level in milli-sievert(s) per hour at 1 meter from the external surface of the package by 100. This result is equivalent to the maximum radiation level in millirems per hour at 1 meter (49 CFR 173.403).

The proper category of label to be applied must be determined in accordance with 49 CFR 172.403(c). The label to be applied must be the highest category required for any of the two determining conditions for the package. The following table illustrates this hierarchy.

Class 7 (Radioactive) Material Labeling Requirements				
TI (at 1 meter)	**Surface Dose Rate**			
	≤ 0.5 mrem/h	> 0.5 ≤ 50 mrem/h	> 50 ≤ 200 mrem/h	> 200 ≤ 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—continued

RADIOACTIVE labels are unusual in that they are the only label that requires the shipper to add information on the label (49 CFR 172.403[g]). Applicable items of information must be entered in blank spaces on the RADIOACTIVE label by legible printing (manual or mechanical), using a durable, weather-resistant means of marking. The following items must be entered on labels in the spaces provided:

- contents (except for LSA-I), 49 CFR 172.403(g)(1)
- activity, and
- TI (RADIOACTIVE YELLOW-II and RADIOACTIVE YELLOW-III labels only).

The contents are indicated by entering the name of the radionuclides as provided in the listing of radionuclides in 49 CFR 173.435. Symbols that conform to established radiation protection terminology are authorized. For mixtures of radionuclides, the radionuclides that must be shown must be determined in accordance with 49 CFR 173.433(g). For LSA-I material, the term “LSA-I” may be entered in place of the radionuclide(s), 49 CFR 172.403(g)(1).

Activities indicated on labels must be expressed in appropriate SI units or in appropriate SI units followed by the customary units. Specific requirements for the transportation of fissile material are found in 49 CFR 173.457 and 173.459. Abbreviations are authorized.

Except for ^{239}Pu and ^{241}Pu, the weight in grams or kilograms of fissile radionuclides may be entered instead of activity units. For ^{239}Pu and ^{241}Pu, the weight in grams or kilograms of fissile radionuclides may be entered, in addition to activity units.

The TI is calculated as indicated in 49 CFR 173.403 and is entered as a unitless number. Values are rounded up to the next tenth. If the measured TI is not found to be greater than 0.05, then it may be considered to be zero.

General Labeling Requirements—continued

The TI is required on RADIOACTIVE YELLOW-II and RADIOACTIVE YELLOW-III labels. If the TI is greater than zero, a RADIOACTIVE WHITE-I label cannot be used. The following table summarizes the entry requirements for RADIOACTIVE labels:

Entry Requirements for RADIOACTIVE Labels				
Label	**Content**	**Activity**	**TI**	**CSI**
RADIOACTIVE WHITE-I	X	X	–	–
RADIOACTIVE YELLOW-II	X	X	X	–
RADIOACTIVE YELLOW-III	X	X	X	–
FISSILE	–	–	–	X

Under some special conditions, packages containing Class 7 (radioactive) material are excepted from general labeling requirements per 49 CFR 172, Subpart E. These special conditions include the following:

- limited quantities,
- instruments or articles meeting the requirements of 49 CFR 173.424,
- LSA material and SCO when shipped domestically under exclusive use per 173.427(a)(6),
- manufactured articles containing only natural or depleted uranium or natural thorium, and
- small quantities per 173.4.

Additional Labeling Requirements

Label Placement

In addition to the above requirements for categorization of labels, the DOT prescribes requirements for the placement of labels (49 CFR 172.406). Each package that is required to be labeled with a RADIOACTIVE and FISSILE label must have two of these labels. Label placement must meet the following requirements:

- one label must be affixed to each of two opposite sides of the package (49 CFR 172.403[f] and 172.406[e][2]),
- one of the two labels must be placed near the proper shipping name and on the same surface (49 CFR 172.406[a][ii]),
- each label must be printed on or affixed to a background of contrasting color or must have a dotted or solid line as an outer border (49 CFR 172.406[d]), and
- the labels must be clearly visible and not obscured by markings or attachments [49 CFR 172.406(f)].

The requirements of 49 CFR 172.403(f) are not fulfilled by labels placed on the bottom of a package (49 CFR 172.406[a][i]).

Labeling for Secondary Hazards

Packages containing Class 7 (radioactive) material may require hazardous material labels in addition to the prescribed RADIOACTIVE labels. Except for LSA material and SCO material, each package containing a radioactive material that also meets the definition of one or more additional hazards, except Class 9, must be labeled as a radioactive material as required by 49 CFR 172.403 and for each additional hazard (49 CFR 172.402[d]).

Paragraph 172.406(c) provides requirements for the placement of multiple labels on packages containing subsidiary hazards. When a package requires both primary and subsidiary hazard labels, the labels must be displayed next to each other. This requirement is met if the labels are placed within 150 mm (6 in.) of one another.

Additional Labeling Requirements—continued

Label Specifications

RADIOACTIVE labels must also conform to DOT-prescribed specifications (49 CFR 172.407), including specifications for

- durability,
- design,
- size, and
- color.

The color must extend only to the inner border on RADIOACTIVE YELLOW-II, RADIOACTIVE YELLOW-III, and FISSILE labels, and the trefoil symbol on the RADIOACTIVE label must conform to the appropriate specifications found in Appendix B of Part 172.

EMPTY Labels

Requirements covering the use of the EMPTY label are stipulated in 49 CFR 173.428. The EMPTY label is used on packages that

- have previously contained radioactive material and
- have been emptied of those contents as far as practical.

Any labels previously applied in conformance to Part 172, Subpart E must be removed, obliterated, or covered with the EMPTY label prescribed in 49 CFR 172.450.

FISSILE Labels

The FISSILE label is used for a package containing fissile material and is addressed in *HMPT: Advanced Radioactive Material Transportation Live*.

Self-Assessment

1. At what distance(s) is (are) radiation dose rate measurements taken to determine the transport index of a package?
2. Calculate the TI for a package with a 50-mrem/h contact reading and a 0.1-mSv/h reading at 1 meter.
3. When is an EMPTY label required on a package?
4. Select the appropriate radioactive material label for the following packages.

Package and Dose Rate Information	Label/s Required
surface = 6 μSv/h (0.6 mrem/h) 1 meter = 1 μSv/h (0.1 mrem/h)	
surface = 0.47 μSv/h (47 mrem/h) 1 meter = 0.06 μSv/h (6 mrem/h)	
fissile material package CSI = 10 surface = 1 μSv/h (0.1 mrem/h) 1 meter = 0.03 μSv/h (0.003 mrem/h)	
empty packaging surface = 4 μSv/h (0.4 mrem/h) 1 meter = undetectable	
HRCQ surface = 1 μSv/h (0.1 mrem/h) 1 meter = undetectable	
fissile material package CSI = 10 surface = 3.8 μSv/h (0.38 mrem/h) 1 meter = 2 μSv/h (0.2 mrem/h)	
limited quantity package surface = 4 μSv/h (0.4 mrem/h) 1 meter = 0.08 μSv/h (0.008 mrem/h)	

5. What information does the shipper have to place on a RADIOACTIVE YELLOW-III label?
6. Where are labels placed on nonbulk Class 7 packages?
7. Of the labels that may be required on a package containing radioactive material, which label(s) require placement on only one side of the package?
8. How are secondary hazards, such as poison and corrosives, indicated on Class 7 packages?

Self-Assessment—continued

9. Where is at least one of the labels for radioactive material placed?
10. Can a label be placed on the bottom of a package?

Answers to Self-Assessment

1. At what distance(s) are radiation dose rate measurements taken to determine the transport index of a package?

   1 meter

2. Calculate the TI for a package with a 50-mrem/h contact reading and a 0.1-mSv/h reading at 1 meter.

   TI = 10

3. When is an EMPTY label required on a package?

   The EMPTY label is used on packages that

   - have previously contained radioactive material and
   - have been emptied of those contents as far as practical.

4. Select the appropriate radioactive material label for the following packages.

Package and Dose Rate Information	Label/s Required
surface = 8 μSv/h (0.6 mrem/h) 1 meter = 1 μSv/h (0.1 mrem/h)	RADIOACTIVE YELLOW-II
surface = 0.47 μSv/h (47 mrem/h) 1 meter = 0.06 μSv/h (6 mrem/h)	RADIOACTIVE YELLOW-III
fissile material package CSI = 10 surface = 1 μSv/h (0.1 mrem/h) 1 meter = 0.03 μSv/h (0.003 mrem/h)	RADIOACTIVE WHITE-I FISSILE
empty packaging surface = 4 μSv/h (0.4 mrem/h) 1 meter = undetectable	EMPTY
HRCQ surface = 1 μSv/h (0.1 mrem/h) 1 meter = undetectable	RADIOACTIVE YELLOW-III
fissile material package CSI = 10 surface = 3.8 μSv/h (0.38 mrem/h) 1 meter = 2 μSv/h (0.2 mrem/h)	RADIOACTIVE YELLOW-II FISSILE
limited quantity package surface = 4 μSv/h (0.4 mrem/h) 1 meter = 0.08 μSv/h (0.008 mrem/h)	None

Answers to Self-Assessment—continued

5. What information does the shipper have to place on a RADIOACTIVE YELLOW-III label?

    - Total activity in the package
    - Identity of the radionuclides
    - TI of the package

6. Where are labels placed on nonbulk Class 7 packages?

    Labels for radioactive material packages are required on two opposite sides of the package, with the exception of the EMPTY label.

7. Of the labels that may be required on a package containing radioactive material, which label(s) requires placement on only one side of the package?

    Empty

8. How are secondary hazards, such as poison and corrosives, indicated on Class 7 packages?

    In most cases, these hazards are indicated with a secondary label. Except for LSA material and SCO material, each package containing a radioactive material that also meets the definition of one or more additional hazards, except Class 9, must be labeled as a radioactive material as required by 49 CFR 172.403 and for each additional hazard (49 CFR 172.402[d]), with labels placed within 6 in. of the Class 7 label.

9. Where is at least one of the labels for radioactive material placed?

    One of the two labels must be placed near the proper shipping name and on the same surface (49 CFR 172.406[a][ii]).

10. Can a label be placed on the bottom of a package?

    No.

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Shipping Paper Requirements for Radioactive Material

Module Objective

Upon completing this module, you will be able to identify the shipping paper entry requirements for radioactive material (Objective 11).

General Shipping Paper Requirements

Unless specifically excepted, all radioactive material requires shipping papers. The DOT requires that shipping paper entries comply with the following general 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 papers may consist of more than one page if

- each page is consecutively numbered and
- the first page is marked to indicate the total number of pages.

Copies of shipping papers must be retained for 2 years after the carrier accepts the shipment. Electronic copies are permitted. If the shipment was hazardous waste, the shipping paper records must be retained for 3 years.

Hazardous Material Description

The DOT prescribes what shipping paper entries must be included in the description of a hazardous material. This description must include (49 CFR 172.202) the:

- identification number from Section 172.101,
- proper shipping name (172.101),
- hazard class (172.101),

Hazardous Material Description—continued

- packing group [not required for Class 7 (radioactive) material] (172.101),
- quantity (by activity for radioactive material), and
- number and type of packages.

Unlike other hazardous materials, packing groups do not apply to Class 7 (radioactive) material and are not provided in column 5 of the 49 CFR 172.101 HMT in association with proper shipping names for radioactive material.

The basic shipping paper description for radioactive material includes the (1) identification number (UN number), (2) proper shipping name, and (3) hazard class. This description must be shown in sequence, with no additional information interspersed. For example, “UN 2982 radioactive material, Type B(M) package, 7.”

Quantity means the total quantity (by net or gross mass, capacity, or as otherwise appropriate), including the unit of measure or activity of the radioactive material. Cylinders of compressed gases and bulk packagings are excepted from the specific mass requirement; however, some indication of total quantity must be shown (e.g., “10 cylinders” or “1 cargo tank”).

The total quantity of the material covered by one description must appear before or after, or both before and after, the description required and authorized by this subpart.

Do not put a hazard class or UN identification number on anything offered for shipment that does not meet the CFR definition of a hazardous material. The regulations demand precision; you cannot mention hazard classes or shipping numbers simply because a material almost meets requirements. To quote the CFR:

> Except for those materials in the UN Recommendations, the International Civil Aviation Organization (ICAO) Technical Instructions, or the International Maritime Dangerous Goods (IMDG) Code, a material that is not a hazardous material according to this subchapter may not be offered for transportation or transported when its description on a shipping paper includes a hazard class or an identification number specified in 49 CFR 172.101.

Additional Description Requirements

The DOT prescribes additional description requirements for the following categories of hazardous materials (49 CFR 172.203):

- Special permits;
- limited quantities (if shipping paper is required);
- hazardous substances;
- Class 7 (radioactive) material; and
- Empty packagings, if residue from previous shipments is present.

A material offered for transportation as limited quantity, as authorized by 49 CFR 171–180, must include the words “Limited Quantity” or “Ltd Qty” following the basic description. Limited quantities of Class 7 (radioactive) material meeting the requirements of 49 CFR 173.421 are excepted from shipping paper requirements unless the material meets the definition of a hazardous substance or hazardous waste.

For each hazardous substance, the letters “RQ” shall be entered on the shipping paper, either before or after the basic description.

For Class 7 (radioactive) material, the following entries are required as discussed in 49 CFR 172.203

- the name of each listed radionuclide in the package (abbreviations as per the 49 CFR 173.435 Table of A1 and A2 Values for Radionuclides are acceptable);
- a description of the physical form (e.g., solid, liquid, or gas) and chemical form of the material;
- for special-form material, the words “special form,” unless those words are already in the proper shipping name;
- the total activity in the package (multiplication prefix symbols are acceptable, e.g., TBq and GBq) (fissile mass may be included);
- the category of label applied (e.g., RADIOACTIVE YELLOW-II);
- the TI assigned to the package in the shipment bearing RADIOACTIVE YELLOW-II or RADIOACTIVE YELLOW-III labels;
- For fissile material, either the words “fissile excepted” or the CSI for the package, as appropriate;
- Package identification marking for packages approved by the DOE or NRC or by the IAEA for export shipments;

Additional Description Requirements—continued

- Indication of exclusive use if applicable;
- the words “Highway Route Controlled Quantity” or the letters “HRCQ” for those shipments that meet this definition.

Note: *Abbreviations, unless specifically authorized, may not be used.*

Shipper’s Certification

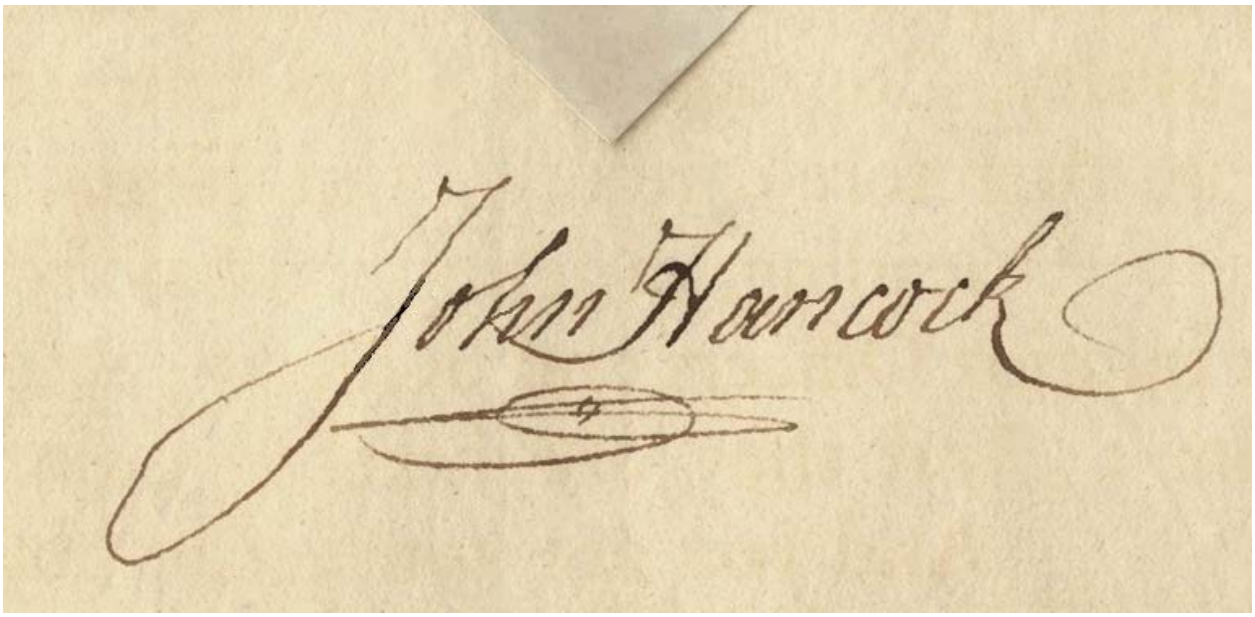
Unless excepted, a shipping paper must also contain

- a certification statement and
- a signature.

The shipper’s certification must be as prescribed in 49 CFR 172.204. Two statements are offered. Both statements certify that the material described in the shipping paper has been properly classified, described, packaged, marked, and labeled and that it is, in all respects, in proper condition for transport according to the applicable rules and regulations.

The certification statement must bear the signature of an authorized person, and the signature must be legible.

Note: *The signature may be typewritten, or other mechanical means may be used.*



Self-Assessment

1. What five elements make up the complete description on a radioactive material shipping paper?
2. When is the RQ required on shipping papers?
3. What does the shipper certify?

Answers to Self-Assessment

1. What five elements make up the complete description on a radioactive material shipping paper?
   - identification number,
   - proper shipping name,
   - hazard class,
   - quantity (by activity for radioactive material), and
   - package type and count.
2. When is the RQ required on shipping papers?

   When the material being shipped is also a hazardous substance.
3. What does the shipper certify?

   That the material described in the shipping paper has been properly classified, described, packaged, marked, and labeled and that it is, in all respects, in proper condition for transport according to the applicable rules and regulations.

Placarding Requirements for Radioactive Material

Module Objective

Upon completing this module, you will be able to select the appropriate placards for a given radioactive material shipment or vehicle load (Objective 12).

General Placarding Requirements

Class 7 (radioactive) material must be placarded as prescribed in Subpart F of Part 172. Only three conditions exist that require a vehicle to display the “RADIOACTIVE” placard (49 CFR 172.504). These conditions occur any time the vehicle is transporting

- packages displaying a RADIOACTIVE YELLOW-III label,
- unpackaged LSA-1 or SCO-1 material,
- fissile material,
- LSA material shipped domestically as exclusive use, or
- SCO shipped domestically as exclusive use.

Unless the transport vehicle is already correctly placarded, it is the responsibility of the shipper to offer the carrier any placards required for the load that the shipper is offering the driver.

Placarding requirements are permissive. Even when not required, hazardous material placards may be displayed, as long as they conform to DOT requirements for placarding and as long as the hazardous material represented is present [49 CFR 172.502(c)].

Additional placarding requirements may apply during the transport of material having subsidiary hazards (49 CFR 172.505).

Placard Location and Configuration

The shipper is responsible for supplying the placards for the material being offered to the carrier. Placards must be offered in sets of four, one for each side of the transport vehicle. The carrier may not accept placards offered by the shipper when the vehicle is already properly placarded or when the placards have already been made available by another shipper.

The shipper is not responsible for material that is already loaded on the transport vehicle.

The carrier is responsible for affixing the placards and for ensuring that the vehicle is properly placarded to communicate all the hazards aboard. The placement of the placards is “diamond-square-on-point” so that the wording and the hazard class/division number can be read horizontally from left to right. One placard of each kind must be placed on all four sides of the transport vehicle. The placards must be displayed so that they are unobstructed and easily seen. The placard must be located away from any markings or advertising on the vehicle.

Specific Placarding Requirements

Because all packages containing an HRCQ must display the RADIOACTIVE YELLOW-III label (49 CFR 172.403[c]), vehicles transporting HRCQ must not only display the “RADIOACTIVE” warning placard but must display it on a square background as described in 49 CFR 172.507(a). Unlike warning placards, the square background must be positioned so that the edges are horizontal and vertical with respect to the ground (49 CFR 172.527).

Self-Assessment

1. List the five transport conditions/loads that require the transport vehicle to be placarded “RADIOACTIVE.”
2. If a vehicle is not already properly placarded, who is responsible for providing the correct placard?
3. When is a rad placard required to be displayed on a square background?

Answers to Self-Assessment

1. List the five transport conditions/loads that require the transport vehicle to be placarded “RADIOACTIVE.”
   - packages displaying a RADIOACTIVE YELLOW-III label,
   - Unpackaged LSA-1 or SCO-1 material,
   - Fissile material,
   - LSA material shipped domestically as exclusive use, or
   - SCO shipped domestically as exclusive use.
2. If a vehicle is not already properly placarded, who is responsible for providing the correct placard?

   The shipper
3. When is a red placard required to be displayed on a square background?

   When it is HRCQ. Because all packages containing an HRCQ must display the RADIOACTIVE YELLOW-III label (49 CFR 172.403[c]), vehicles transporting HRCQ must not only display the “RADIOACTIVE” warning placard, but they must display it on a square background as described in 49 CFR 172.507(a). Unlike warning placards, the square background must be positioned so that the edges are horizontal and vertical with respect to the ground (49 CFR 172.527).

Additional Transportation Requirements and Limitations

Module Objectives

Upon completing this module, you will be able to identify allowable transport limits and unacceptable transport conditions for radioactive material (Objective 13).

General Requirements and Limitations

The transport of radioactive material is subject to many general limitations, including the following:

- radiation levels at package external surfaces (49 CFR 173.441[a]);
- TI (49 CFR 173.441[a])
  - ≤10 in nonexclusive-use conveyance;
- Exclusive-use instructions (49 CFR 173.441[(b] and [c])
  - radiation levels at vehicle lateral surfaces;
  - occupant exposures;
- conveyance limits (49 CFR 173.441[d]);
- thermal limits (49 CFR 173.442);
- contamination levels (49 CFR 173.443)
  - package external surfaces;
  - vehicle limits;
- fissile material (49 CFR 173.453)
  - fissile material, exceptions (49 CFR 173.453);
  - fissile material, criticality safety index (49 CFR 173.457);
  - mixing of fissile material packages with nonfissile or fissile-excepted material packages (49 CFR 173.459);
- loading and unloading requirements for radioactive material (49 CFR 177.842);
- vehicle contamination (49 CFR 177.843); and
- segregation and separation of hazardous materials (49 CFR 177.848).

General Requirements and Limitations—continued

Requirements applicable to exclusive-use shipments and to the transport of fissile material will be addressed in *HMPT: Advanced Radioactive Material Transportation Live*. A more detailed discussion of the remaining requirements follows.

Package Radiation Level and Transport Index Limits

Except when consigned as exclusive use, each package of Class 7 (radioactive) material that is offered for transportation must be designed and prepared for shipment so that, under conditions normally incident to transportation (49 CFR 173.441[a]),

- the radiation level does not exceed 2 mSv/h (200 mrem/h) at any point on the external surface of the package and
- the TI does not exceed 10.

Packages that exceed these radiation limits must be consigned as exclusive use if the shipment meets specific requirements.

Package Thermal Limits

A package of Class 7 (radioactive) material must be designed, constructed, and loaded so that (49 CFR 173.442)

- the heat generated within the package by the radioactive contents will not, during conditions normally incident to transport, affect the integrity of the package; and
- the temperature of the accessible external surfaces of the loaded package will not, assuming still air in the shade at an ambient temperature of 38°C (100°F), exceed 50°C (122°F) in other than an exclusive-use shipment and will not exceed 85°C (185°F) in an exclusive-use shipment.

Package Thermal Limits—continued

Except as provided in 174.81 (Segregation for Rail), 176.83 (Segregation for Vessel), and 177.848 (Segregation for Highway) or as required by the competent authority in the applicable certificate, a package or overpack of Class 7 (radioactive) material may be carried among general cargo without special stowage provisions if

- the heat output in watts does not exceed 0.1 times the minimum package in centimeters, or
- the average surface heat flux of the package or overpack does not exceed 15 watts per square meter and the immediate surrounding cargo is not in sacks or bags or otherwise in a form that would seriously impede air circulation for heat removal.

Package Surface Contamination Limits

Table 9 in 49 CFR 173.443, which provides nonfixed surface radioactive contamination limits, is represented below.

Maximum Permissible Limits			
Contaminant	**Bq/cm^2**	**μCi/cm^2**	**Dpm/cm^2**
Beta and gamma emitters and low-toxicity alpha emitters	4	10^{-4}	240
All other alpha-emitting radionuclides	0.4	10^{-5}	24

The DOT defines low-toxicity alpha emitters as (49 CFR 173.403)

- natural uranium, depleted uranium, and natural thorium;
- ^{235}U or ^{238}U;
- ^{232}Th;
- ^{228}Th and ^{230}Th when contained in ores or physical and chemical concentrates; or
- alpha emitters with a half-life of <10 days.

Special provisions apply to packages transported by and vehicles used in exclusive-use shipments.

Loading and Unloading Requirements

The DOT prescribes limits on the total amount of Class 7 (radioactive) material that may be loaded in a single vehicle or stored in a single location (49 CFR 177.842). The number of packages of Class 7 (radioactive) material in any transport vehicle or storage location must be limited so that the total TI number does not exceed 50.

The total TI of a group of packages and overpacks is determined by adding together the TI number on the labels on the individual packages and overpacks in the group.

The DOT also prescribes, in 49 CFR 177.842 and 49 CFR 177.870(g), minimum separation distances between packages containing radioactive material and areas that may be continuously occupied by people, animals, or undeveloped film. Minimum separation distances must be measured from the nearest point on the nearest packages of Class 7 (radioactive) material.

Loading and Unloading Requirements—continued

Packages of Class 7 (radioactive) material bearing RADIOACTIVE YELLOW-II and RADIOACTIVE YELLOW-III labels may not be placed in a transport vehicle, storage location, or any other place closer than the distances prescribed in the table provided in 49 CFR 177.842 to any area that may be continuously occupied by any

- passenger,
- employee, or
- animal.

Minimum separation distances between packages containing radioactive material and packages containing undeveloped film, if so marked, are also prescribed and provided in the same table. The minimum separation distance depends on

- the total TI; and
- whether the radioactive material is being separated from
  - people,
  - animals, or
  - film
    - for film, the transit time.

Loading and Unloading Requirements—continued

If more than one package containing radioactive material is present, the minimum separation distances must be computed on the basis of the total TI number, which must be determined by adding together the TI numbers listed on the labels on the individual packages and overpacks in the vehicle or storage area.

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

Packages must be blocked and braced so that they cannot change position during conditions normally incident to transportation (49 CFR 177.842[d]), and persons should not remain unnecessarily in a vehicle containing Class 7 material (49 CFR 177.842[e]).

Segregation and Separation of Hazardous Materials

Materials that meet one or more of the hazard classes defined in 49 CFR Parts 171–180 may not be loaded, transported, or stored together, except as provided in 49 CFR 177.848 and in accordance with the Segregation Table for Hazardous Materials provided in that section. A detailed discussion of these requirements is provided in the course *HMPT: Movement by Highway Live*.

Self-Assessment

1. What are the general radiation level limits for nonexclusive-use packages of Class 7 material?
2. Identify the maximum package contamination limits for the following shipments consigned as a common carrier.

Contaminant	uCi/cm^2	Dpm/cm^2
Beta and gamma emitters and low-toxicity alpha emitters		
All other alpha-emitting radionuclides		

3. What is the maximum TI for a vehicle that is not being used for exclusive use?
4. Provide three examples of a low-toxicity alpha emitter.
5. In a storage location, what is the minimum distance that one group of packages of radioactive material may be to another?
6. When determining the proximity to personnel of radioactive packages in a vehicle, which DOT regulation is applicable?

Answers to Self-Assessment

1. What are the general radiation level limits for nonexclusive-use packages of Class 7 material?

   200-mrem/h maximum on contact with the package.

   A TI of less than 10.

2. Identify the maximum package contamination limits for the following shipments consigned as a common carrier.

Contaminant	uCi/cm^2	Dpm/cm^2
Beta and gamma emitters and low-toxicity alpha emitters	10^{-4}	240
All other alpha-emitting radionuclides	10^{-5}	24

3. What is the maximum TI for a vehicle that is not being used for exclusive use?

   50

4. Provide three examples of a low-toxicity alpha emitter.

   Any of the following

   - natural uranium, depleted uranium, and natural thorium;
   - ^{235}U or ^{238}U;
   - ^{232}Th;
   - ^{228Th} and ^{230}Th when contained in ores or physical and chemical concentrates; or
   - alpha emitters with a half-life of less than 10 days.

5. In a storage location, what is the minimum distance that one group of packages of radioactive material may be to another?

   20ft

6. When determining the proximity to personnel of radioactive packages in a vehicle, which DOT regulation is applicable?

   49CFR177.842

SHIPPER'S CERTIFICATION FOR RADIOACTIVE MATERIALS

Two completed and signed copies of this certification shall be handed to the carrier.
(Use block letters)

WARNING: Failure to comply in all respects with the applicable regulations of the Department of Transportation, 49-CFR, CAB 82 and, for international shipments, the IATA Restricted Articles Regulations may be a breach of the applicable law, subject to legal penalities. This certification shall in no circumstances be signed by an IATA Cargo Agent or a consolidator for international shipments.

This shipment is within the limitations prescribed for (mark one)
X passanger aircraft cargo-only aircraft

NATURE AND QUANTITY OF CONTENT					PACKAGE			
PROPER SHIPPING NAME	RADIONUCUDE	GROUP	FORM	ACTIVITY		CATEGORY	TRANSPORT INDEX	TYPE
FOR US SHIPMENTS SEE SECTION 2 CAB 82 TABLE 6-0	NAME OR SYMBOL OF PRINCIPAL RADIOACTIVE CONTENT	GROUP NUMBER OF GROUPS I TO VII	CHEMICAL FORM AND PHYSICAL STATE: GAS LIQUID, SOLID or SPECIAL FORM or SPECIAL ENCAPSULATION	NUMBER OF CURIES OR MILLICURIES	NUMBER OF PACKAGES	I-WHITE OR II-YELLOW OR III-YELLOW LABEL	FOR YELOW LABEL CATEGORIES ONLY	INDUSTRIAL OR TYPE A OR TYPE B

ADDITIONAL INFORMATION REQUIRED FOR FISSILE MATERIALS ONLY

EXEMPTED FROM THE ADDITIONAL REQUIREMENTS FOR FISSILE MATERIALS SPECIFIED IN / 1 OF PART 2 OF THE IATA RESTRICTED ARTICLES REGULATIONS
NAMES PLUS QUANTITY IN GRAMS OR CONCENTRATION OR ENRICHMENT IN U235

NOT EXEMPTED FISSILE CLASS I FISSILE CLASS II FISSILE CLASS III

Additional certificates obtained by the Shipper when necessary N/A
Special Form Encapsulation Certificate(s)
Type B Packaging Certificate(s)
Certificates for Fissile Material
Certificate(s) for Large Radioactive Source
Government Approvals / Permits

Special Handling Information

NONE

I hereby certify that the contents of this consignment are fully and accurately described above by Proper Shipping Name and are classified, packed, marked, labeled and in proper condition for carriage by air according to applicable national governmental regulations, and for international shipments. The current IATA Restricted Articles Regulations.

Name and full address of Shipper	Name and title of person signing Certification
Date:	Signature of the Shipper (see WARNING above)

Air Waybill No:	Airport of Departure:	Airport of Destination

Notes . . .

Appendix: Problems and Solutions

Basic Radioactive Material Transportation

Course #30462

Wednesday Activities

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Basic Radioactive Material Transportation, Problem Number 1

Provide the information necessary to transport the following shipment by highway under unilateral agreement: 55 kg of soil contaminated with 1×10^{-4} TBq of ^{241}Am (alpha emitter: normal form). The highest dose rate at any point on the surface of the package is 0.06 mrem/h, and the highest dose rate at any point 1 meter from the package surface is 0.02 mrem/h. Surface contamination = 0.5 Bq/cm^2. Do not consider LSA options.

Activity: HAVE = 1×10^{-4} TBq = 1×10^{-4} TBq × 1×10^{12} Bq = 1×10^{8} Bq
TBq

Class 7: Activity limit for exempt consignment = 1×10^{4} Bq EXEMPT NONEXEMPT
HAVE specific activity = 1×10^{8} Bq/ $55 \times g$ = 1818 Bq/g EXEMPT
Activity concentration for exempt material = 1 Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A_ = _____ TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > _____ TBq IS NOT RQ? IS RQ?

UN#: _____ **Proper Shipping Name**: _____

Identify Any Subsidiary Hazard Class/Division/s: _____

Packaging Type: Excepted package? Type A? Type B?

Marking(s):

Label(s): None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI =_____ Contents =_____ Activity = _____
Subsidiary labels = _____

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: _____

Additional Requirement(s): (for example: conditions requiring correction before the package is shipped)

DOT Shipping Papers:

HM	Description	Quantity

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Basic Radioactive Material Transportation, Problem Number 2

Provide the information necessary to transport the following shipment by highway: 10 g of calcium bicarbonate containing 45 MBq of ^{45}Ca dissolved in 1 liter of water (1000 g). The highest dose rate at any point on the surface of the package is 0.015 mrem/h, and the highest dose rate at any point 1 meter from the package surface is 0.02 mrem/h. No surface contamination is detectable.

Activity: HAVE = 45×10^{-6} TBq = $45 \times 10^{-6} \times 1 \times 10^{12} = 4.5 \times 10^{7}$ Bq

Class 7: Activity limit for exempt consignment = 1×10^{7} Bq EXEMPT NONEXEMPT
HAVE specific activity = 4.5×10^{7} Bq/ 1010 g = 4.5×10^{4} Bq/g EXEMPT
Activity concentration for exempt material = 1×10^{4} Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A_ = _____TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > _____TBq IS NOT RQ? IS RQ?

UN#: _____ **Proper Shipping Name**:_____

Identify Any Subsidiary Hazard Class/Division/s: _____

Packaging Type: Excepted package? Type A? Type B?

Marking(s):

Label(s): None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI =_____ Contents =_____Activity = _____
Subsidiary labels = _____

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: _____

Additional Requirement(s): (for example: conditions requiring correction before the package is shipped)

DOT Shipping Papers:

HM	Description	Quantity

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Basic Radioactive Material Transportation, Problem Number 3

Provide the information necessary to transport the following shipment by highway: A 200-kg package containing 1100 TBq of ^{197}Hg (liquid, metal). The highest dose rate at any point on the surface of the package is 45 mrem/h. The highest dose rate at any point 1 meter from the surface of the package is 0.14 mrem/h. This material is being shipped under a unilateral agreement.

Activity: HAVE = 1100 TBq = $1100 \times 1 \times 10^{12} = 1.1 \times 10^{15}$ Bq

Class 7: Activity limit for exempt consignment = 1.1×10^{7} Bq EXEMPT NONEXEMPT
HAVE specific activity = 1.1×10^{15} Bq/ 200×10^{3} g = 5.5×10^{2} Bq/g EXEMPT
Activity concentration for exempt material = 1.0×10^{2} Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A_ = _____TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > _____TBq IS NOT RQ? IS RQ?

UN#: _____ **Proper Shipping Name**: _____

Identify Any Subsidiary Hazard Class/Division/s: _____

Packaging Type: Excepted package? Type A? Type B?

Marking(s):

Label(s): None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI =_____ Contents =_____Activity = _____
Subsidiary labels = _____

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: _____

Additional requirement(s): (for example: conditions requiring correction before the package is shipped)

DOT Shipping Papers:

HM	Description	Quantity

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Basic Radioactive Material Transportation, Problem Number 4

Provide the information necessary to transport the following by highway: A package containing 0.14 GBq of ^{137}Cs (cesium sulfate, solid) in normal form. The assembled package weighs 22 kg. The highest dose rate at any point of the surface of the package is 205 mrem/h. The highest dose rate at any point 1 meter from the surface of the package is 10.4 mrem/h.

Activity: HAVE = 0.14×10^{-3} TBq = $0.14 \times 10^{-3} \times 10^{12} = 1.4 \times 10^{8}$ Bq

Class 7: Activity limit for exempt consignment = 1×10^{4} Bq EXEMPT NONEXEMPT
Specific activity = 1.4×10^{8} Bq/ 22×10^{3} g = 6363 Bq/g EXEMPT
Activity concentration for exempt material = 1×10^{1} Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A_= _____TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > _____TBq IS NOT RQ? IS RQ?

UN#: _____ **Proper Shipping Name**:_____

Identify Any Subsidiary Hazard Class/Division/s: _____

Packaging Type: Excepted package? Type A? Type B?

Marking(s):

Label(s): None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI =_____ Contents =_____Activity = _____
Subsidiary labels = _____

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: _____

Additional Requirement(s): (for example: conditions requiring correction before the package is shipped)

DOT Shipping Papers:

HM	Description	Quantity

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Basic Radioactive Material Transportation, Problem Number 5

Provide the information necessary to transport the following shipment by highway: A 2-kg package containing 500 MBq of ^{60}Co as $CoCl_2$ (solid) in normal form. The highest dose rate at any point on the surface is 0.6 mrem/h. The highest dose rate at any point 1 meter from the surface of the package is 0.08 mrem/h. No surface contamination is detectable. Do not consider LSA options.

Activity: HAVE = 500×10^{-6} TBq = $500 \times 10^{-6} \times 10^{12} = 5.0 \times 10^{8}$ Bq

Class 7: Activity limit for exempt consignment = 1.0×10^{5} Bq EXEMPT NONEXEMPT
HAVE specific activity = 5.0×10^{8} Bq/ 2.0×10^{3} g = 2.5×10^{5} Bq/g EXEMPT
Activity concentration for exempt material = 1.0×10^{1} Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A_ = _____TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > _____TBq IS NOT RQ? IS RQ?

UN#: _____ **Proper Shipping Name**:_____

Identify Any Subsidiary Hazard Class/Division/s: _____

Packaging Type: Excepted package? Type A? Type B?

Marking(s):

Label(s): None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI =_____ Contents =_____Activity = _____
Subsidiary labels = _____

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: _____

Additional Requirement(s): (for example: conditions requiring correction before the package is shipped)

DOT Shipping Papers:

HM	Description	Quantity

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Basic Radioactive Material Transportation, Problem Number 6

Provide the information necessary to transport the following shipment by highway: three packages, each containing 16 TBq of ^{227}Th as thorium nitrate in solid form. Each package weighs 68 kg, has a maximum surface dose rate of 3 mrem/h, and has a maximum dose rate at 1 meter of 0.15 mrem/h. No surface contamination is detectable. The packages are shipped under multilateral agreement.

Activity: HAVE = 16 TBq = 16×10^{12} = 1.6×10^{13} Bq

Class 7: Activity limit for exempt consignment = 1×10^{4} Bq — EXEMPT NONEXEMPT
Specific activity = 1.6×10^{13} Bq/ (68×10^{3}) g = 2.4×10^{8} Bq/g — EXEMPT
Activity concentration for exempt material = 1.0×10^{1} Bq/g — NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A_ = _____TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > _____TBq IS NOT RQ? IS RQ?

UN#: _____ **Proper Shipping Name**:_____

Identify Any Subsidiary Hazard Class/Division/s: _____

Packaging Type: Excepted package? Type A? Type B?

Marking(s):

Label(s): None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI =_____ Contents =_____Activity = _____
Subsidiary labels = _____

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: _____

Additional requirement(s): (for example: conditions requiring correction before the package is shipped)

DOT Shipping Papers:

HM	Description	Quantity

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Basic Radioactive Material Transportation, Problem Number 7

Provide the information necessary to transport the following shipment by highway: Soil (200 kg) contaminated with 10 KBq of ^{238}Pu, normal form, surface dose rate = 0.2 mrem/h, dose rate at 1 meter of 0.2 mrem/h, no surface contamination detectable. Shipped under unilateral agreement.

Activity: HAVE = 10×10^{-9} TBq = $10 \times 10^{-9} \times 10^{12} = 1.0 \times 10^{4}$ Bq

Class 7: Activity limit for exempt consignment = 1.0×10^{4} Bq EXEMPT NONEXEMPT
Specific activity = 1.0×10^{4} Bq/ 200×10^{3} g = 0.05 Bq/g EXEMPT
Activity concentration for exempt material = 1.0 Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A_ = _____ TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > _____ TBq IS NOT RQ? IS RQ?

UN#: _____ **Proper Shipping Name**: _____

Identify Any Subsidiary Hazard Class/Division/s: _____

Packaging Type: Excepted package? Type A? Type B?

Marking(s):

Label(s): None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI = _____ Contents = _____ Activity = _____
Subsidiary labels = _____

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: _____

Additional Requirement(s): (for example: conditions requiring correction before the package is shipped)

DOT Shipping Papers:

HM	Description	Quantity

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Solution for Radioactive Material Transportation, Problem Number 1

Provide the information necessary to transport the following shipment by highway: 55 kg of soil contaminated with 1×10^{-4} TBq of ^{241}Am (alpha emitter: normal form). The highest dose rate at any point on the surface of the package is 0.06 mrem/h, and the highest dose rate at any point 1 meter from the package surface is 0.02 mrem/h. Surface contamination = 0.5 Bq/cm^2. (Do not consider LSA options.)

Activity: HAVE = 1×10^{-4} TBq = 1×10^{-4} TBq × 1×10^{12} Bq/TBq = 1×10^{8} Bq

Class 7: Activity limit for exempt consignment = 1×10^{4} Bq EXEMPT NONEXEMPT
HAVE specific activity = 1×10^{8} Bq/ 55×10^{3} g = 1818 Bq/g EXEMPT
Activity concentration for exempt material = 1 Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A 2 = $1x10^{-3}$ TBq > $1x10^{-4}$ TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > 0.00037 TBq IS NOT RQ? IS RQ?

UN# 2915 , **Proper Shipping Name**: Radioactive material, Type-A package

Identify Any Subsidiary Hazard Class/Division/s: None

Packaging Type: Excepted package? Type A? Type B?

Marking(s): UN 2915, Radioactive material, Type-A package, TO/FROM

And Additional Radioactive Marking(s): 55 kg, TYPE A, USA

Label(s) for TI = 0.0**,** None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI = None Contents = ^{241}Am Activity = 1×10^{-4} TBq
Subsidiary labels = None

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: None

Additional requirement(s): (for example: conditions requiring correction before the package is shipped) Alpha emitter contamination limit is 0.4 Bq/cm^2. Package has 0.5 Bq/cm^2, which must be reduced before shipment.

DOT Shipping Papers:

HM	Description	Quantity
X	UN 2915, Radioactive material, TYPE-A package, 7,	55 kg
	^{241}Am, solid, soil, 1×10^{-4} TBq,	
	RADIOACTIVE WHITE-I, TI = 0.0, (800) HELPMEE	
	Shipper's certification statement and signature	

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Solution for Radioactive Material Transportation, Problem Number 2

Provide the information necessary to transport the following shipment by highway: 10 g of calcium bicarbonate containing 45 MBq of ^{45}Ca dissolved in 1 liter of water (1000 g). The highest dose rate at any point on the surface of the package is 0.015 mrem/h, and the highest dose rate at any point 1 meter from the package surface is 0.02 mrem/h. No surface contamination is detectable.

Activity: HAVE = 45×10^{-6} TBq = $45 \times 10^{-6} \times 1 \times 10^{12} = 4.5 \times 10^{7}$ Bq
= 0.000045

Class 7: Activity limit for exempt consignment = 1×10^{7} Bq EXEMPT NONEXEMPT
HAVE specific activity = 4.5×10^{7} Bq/ 1010 g = 4.5×10^{4} Bq/g EXEMPT
Activity concentration for exempt material = 1×10^{4} Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A 2 = 1.0 TBq

$10^{-4} \times A\ 2 = 0.0001$

Minimum Shipping Category: HRCQ? Type B? Type A? Limited Quantity?

Hazardous Substance: RQ limit = or > 0.37 TBq IS NOT RQ? IS RQ?

UN# 2910 **Proper Shipping Name**: Radioactive material, excepted package, limited quantity of material,

Identify Any Subsidiary Hazard Class/Division/s: None

Packaging Type: Excepted package? Type A? Type B?

Marking(s): UN 2910, "Radioactive" on inner package or outer package if no inner package

Label(s) for TI = ___ None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI = -- Contents = -- Activity = --
Subsidiary labels = None

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: None

Additional Requirement(s): (for example: conditions requiring correction before the package is shipped)
None

DOT Shipping Papers: None

HM	Description	Quantity

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Solution for Radioactive Material Transportation, Problem Number 3

Provide the information necessary to transport the following shipment by highway under unilateral agreement: A 200-kg package containing 1100 TBq of ^{197}Hg (liquid, metal). The highest dose rate at any point on the surface of the package is 45 mrem/h. The highest dose rate at any point 1 meter from the surface of the package is 0.14 mrem/h.

Activity: HAVE = 1100 TBq = 11001 × 10^{12} = 1.1 × 10^{15} Bq

Class 7: Activity limit for exempt consignment = 1.1 × 10^{7} Bq EXEMPT NONEXEMPT
Specific activity = 1.1 × 10^{15} Bq/ 200 × 10^{3} g = 5.5 × 10^{2} Bq/g EXEMPT
Activity concentration for exempt material = 1.0 × 10^{2} Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A 2 = 1.0 × 10^{1} TBq

Minimum Shipping Category: HRCQ Type B? Type A? Limited Quantity?

Hazardous Substance: RQ limit = or > 37 TBq IS NOT RQ? `IS RQ

UN# 2916, **Proper Shipping Name**: Radioactive material, Type-B(U) package

Identify Any Subsidiary Hazard Class/Division/s: None

Packaging Type: Excepted package? Type A? Type B?

Marking(s): RQ, UN 2916, radioactive material, Type B(U) package, TO/FROM, 200 Kg, TYPE B(U), trefoil, CoC#

Label(s) for TI = 0.2 , None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI = 0.2 , Contents = ^{197}Hg Activity = 1100 TBq
Subsidiary labels = None

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: None

Additional Requirement(s): (for example: conditions requiring correction before the package is shipped)
None

DOT Shipping Papers:

HM	Description	Quantity
RQ	UN 2916, radioactive material, Type-B(U) package, 7, (mercury),	200 kg
	HRCQ, ^{197}Hg, liquid, metal, 1100 TBq,	
	Radioactive Yellow-III, TI = 0.2,	
	TYPE B, CoC#,	
	(800) HELPMEE,	
	Shipper's certification statement and signature	

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Solution for Radioactive Material Transportation, Problem Number 4

Provide the information necessary to transport the following by highway: A package containing 0.14 GBq of ^{137}Cs (cesium sulfate, solid) in normal form. The assembled package weighs 22 kg. The highest dose rate at any point of the surface of the package is 205 mrem/h. The highest dose rate at any point 1 meter from the surface of the package is 10.4 mrem/h.

Activity: HAVE = 0.14×10^{-3} TBq = $0.14 \times 10^{-3} \times 10^{12} = 1.4 \times 10^{8}$ Bq

Class 7: Activity limit for exempt consignment = 1×10^{4} Bq EXEMPT NONEXEMPT
Specific activity = 1.4×10^{8} Bq/ 22×10^{3} g = 6363 Bq/g EXEMPT
Activity concentration for exempt material = 1×10^{1} Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A 2 = 6×10^{-1} TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > 0.037 TBq IS NOT RQ? IS RQ?

UN# 2915 **Proper Shipping Name**: "Radioactive material, Type-A package"

Identify Any Subsidiary Hazard Class/Division/s: None

Packaging Type: Excepted package? Type A? Type B?

Marking(s): UN 2915, radioactive material, Type-A package, TO/FROM, TYPE A, USA

Label(s) for TI = 10.4 , None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI = 10.4, Contents = ^{137}Cs Activity = 0.14 GBq
Subsidiary labels = None

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: None

Additional requirement(s): (for example: conditions requiring correction before the package is shipped)
With indicated package surface and 1-meter dose rates, transport would have to be by exclusive use. The dose rates at the package surface and at 1 meter from the package surface are both too high for transport by common carrier.

DOT Shipping Papers:

HM	Description	Quantity
X	UN 2915, radioactive material, TYPE-A package, 7,	22 kg
	^{137}Cs, solid, sulfate, 0.14 GBq, RADIOACTIVE YELLOW-III, TI = 10.4,	
	EXCLUSIVE-USE SHIPMENT	
	(800) HELPMEE	
	Shipper's certification statement and signature	
	Instructions to the carrier for the maintenance of exclusive use.	

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Solution for Radioactive Material Transportation Problem Number 5

Provide the information necessary to transport the following shipment by highway: A 2-kg package containing 500 MBq of ^{60}Co as $CoCl_2$ (solid) in normal form. The highest dose rate at any point on the surface is 0.6 mrem/h. The highest dose rate at any point 1 meter from the surface of the package is 0.08 mrem/h. No surface contamination is detectable. Do not consider LSA options.

Activity: HAVE = 500×10^{-6} TBq = $500 \times 10^{-6} \times 1 \times 10^{12}$ = 5.0×10^{8} Bq

Class 7: Activity limit for exempt consignment = 1.0×10^{5} Bq EXEMPT NONEXEMPT
HAVE specific activity = 5.0×10^{8} Bq/ 2.0×10^{3} g = 2.5×10^{5} Bq/g EXEMPT
Activity concentration for exempt material = 1.0×10^{1} Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A 2 = 4.0×10^{-1} TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > 0.37 TBq IS NOT RQ? IS RQ?

UN# 2915 **Proper Shipping Name**: "Radioactive material, Type A package"

Identify Any Subsidiary Hazard Class/Division/s: None

Packaging Type: Excepted package? Type A? Type B?

Marking(s): UN 2915, "Radioactive material, Type-A package", TO/FROM, TYPE A, USA

Label(s) for TI = 0.1 , None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI = 0.1 , Contents = ^{60}Co Activity = 500 MBq
Subsidiary labels = None

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: None

Additional requirement(s): (for example: conditions requiring correction prior to shipment)
None

DOT Shipping Papers:

HM	Description	Quantity
X	UN 2915, radioactive material, TYPE-A package, 7,	2 kg
	^{60}Co, solid, chloride, 500 MBq,	
	RADIOACTIVE YELLOW-II, TI = 0.1	
	(800) HELPMEE	
	Shippers certification statement and signature	

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Solution for Radioactive Material Transportation Problem Number 6

Provide the information necessary to transport the following shipment by highway: three packages, each containing 16 TBq of ^{227}Th as thorium nitrate in solid form. Each package weighs 68 kg, has a maximum surface dose rate of 3 mrem/h, and has a maximum dose rate at 1 meter of 0.15 mrem/h. No surface contamination is detectable. The packages are shipped under multilateral agreement.

Activity: HAVE = 16 TBq = 16×10^{12} = 1.6×10^{13} B

Class 7: Activity limit for exempt consignment = 1×10^{4} Bq — EXEMPT NONEXEMPT
Specific activity = 1.6×10^{13} Bq/ (68×10^{3}) g = 2.4×10^{8} Bq/g — EXEMPT
Activity concentration for exempt material = 1.0×10^{1} Bq/g — NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A 2 = 5×10^{-3} TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > 0.037 TBq IS NOT RQ? IS RQ?

UN# 2917 **Proper Shipping Name**: "Radioactive material, Type-B(M) package"

Identify Any Subsidiary Hazard Class/Division/s: None

Packaging Type: Excepted package? Type A? Type B?

Marking(s): RQ, UN 2917, radioactive material, Type-B(M) package, TO/FROM, 68 kg, TYPE B (M), radiation symbol (trefoil), CoC#

Label(s) for TI = 0.2 , None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI = 0.2 , Contents = ^{227}Th Activity = 16 TBq
Subsidiary labels = None

Placards: None? Class 7? Class 7 on white background with black border?
Subsidiary placards: None

Additional requirement(s): (for example: conditions requiring correction before the package is shipped)
None

DOT Shipping Papers:

HM	Description	Quantity
RQ	UN 2917, radioactive material, TYPE B(M) package, 7,	Three packages
	HRCQ, ^{227}Th, solid, nitrate, 16 TBq,	Each weighing
	RADIOACTIVE YELLOW-III, TI = 0.2,	68 kg
	TYPE B, CoC#,	
	(800) HELPMEE	
	Shipper's certification statement and signature	

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Solution for Radioactive Material Transportation Problem Number 7

Provide the information necessary to transport the following shipment by highway: Soil (200 kg) contaminated with 10 KBq of ^{238}Pu, normal form, surface dose rate = 0.2 mrem/h, dose rate at 1 meter of 0.2 mrem/h, no surface contamination detectable. Shipped under unilateral agreement.

Activity: HAVE = 10×10^{-9} TBq = $10 \times 10^{-9} \times 1 \times 10^{12}$ = 1.0×10^{4} Bq

Class 7: Activity limit for exempt consignment = 1.0×10^{4} Bq EXEMPT NONEXEMPT
HAVE specific activity = 1.0×10^{4} Bq/ 200×10^{3} g = 0.05 Bq/g EXEMPT
Activity concentration for exempt material = 1.0 Bq/g NONEXEMPT

Class 7: YES? NO?

A Value: Special form? Normal form? A_ = _____TBq

Minimum Shipping Category: HRCQ? Type B? Type A? Limited quantity?

Hazardous Substance: RQ limit = or > _____TBq IS NOT RQ? IS RQ?

UN# _____ **Proper Shipping Name**:_____

Identify Any Subsidiary Hazard Class/Division/s: ___None_____

Packaging Type: No requirements Excepted package? Type A? Type B?

Marking(s): None

Label(s) for TI = _, None? Empty? White-I? Yellow-II? Yellow-III? Fissile?

Label entries: TI =___, Contents =___ Activity = _____
Subsidiary labels = _____

Placards: Class 7? Class 7 on white background with black border?
Subsidiary placards: _____

Additional requirement(s): (for example: conditions requiring correction before the package is shipped)
None

DOT Shipping Papers:

HM	Description	Quantity
	Not required. Material does not meet the DOT definition of a radioactive material.	

Notes . . .

Hazardous Material Packaging and Transportation

Department of Energy
National Transportation
Program

LANL #30462 - Basic
Radioactive Material
Transportation

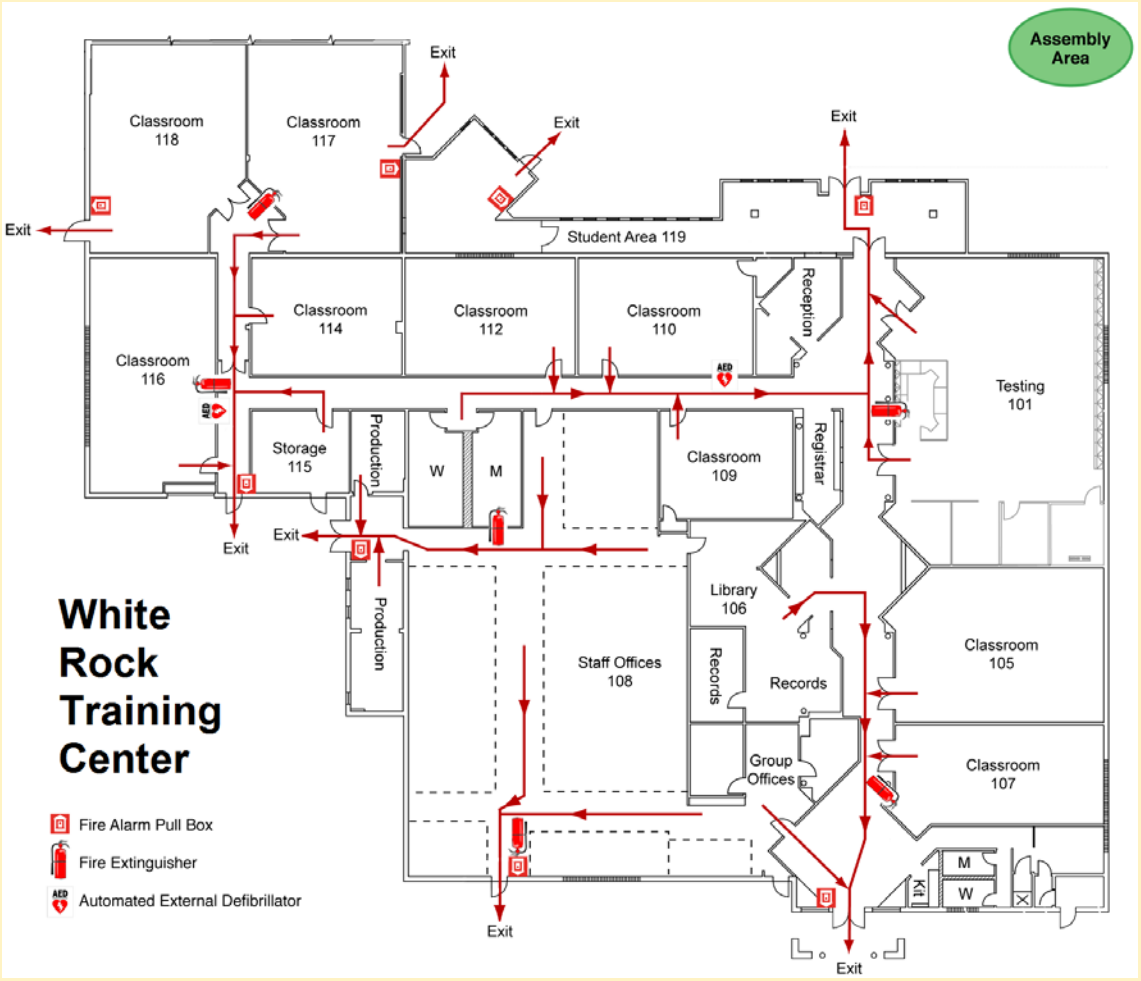
January 2016 – Part 1

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



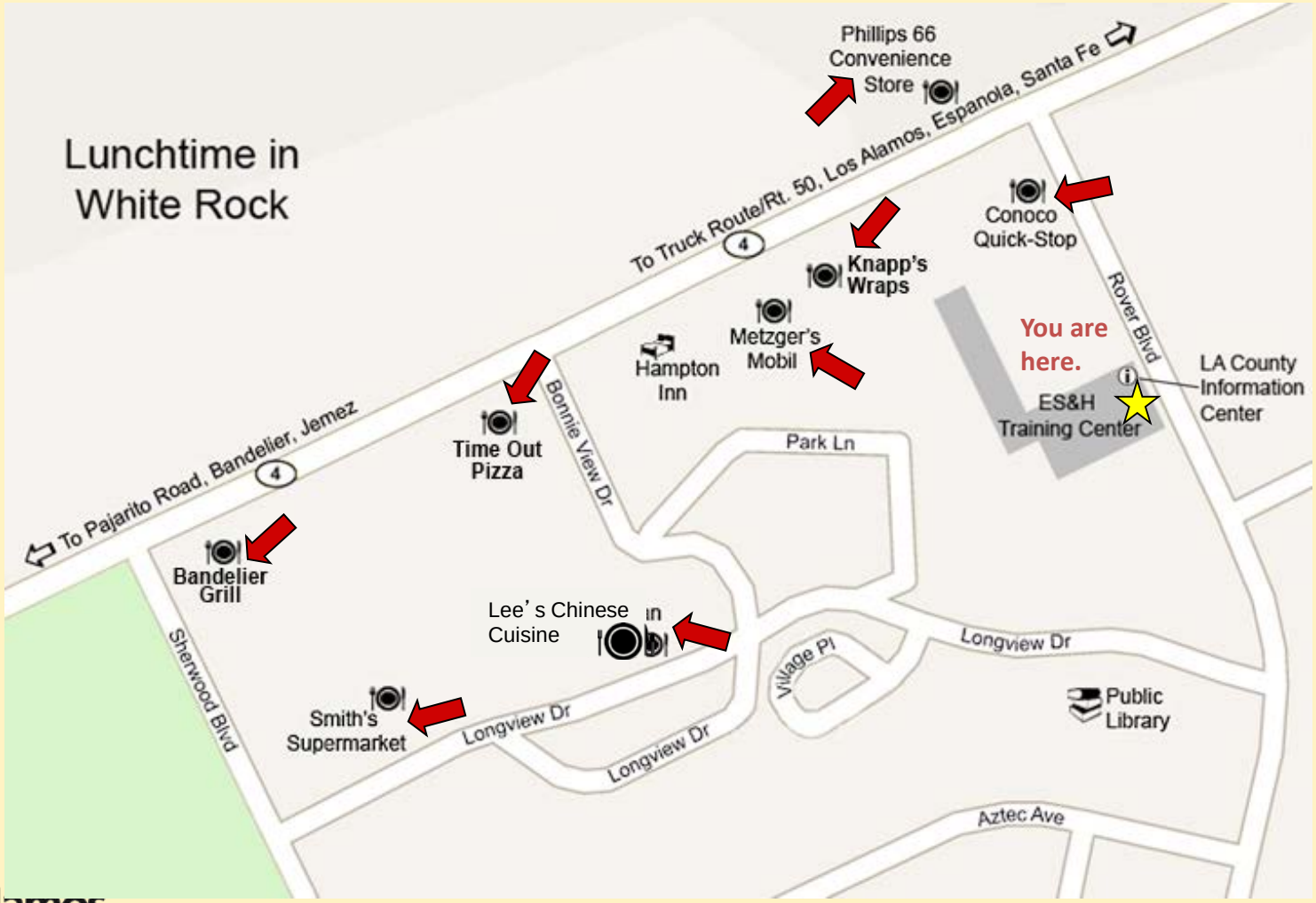
Go to the assembly area when you exit for an emergency.

- 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)

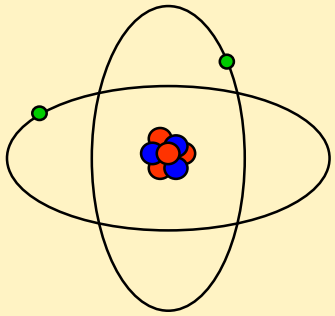
DOT Training Requirements

- 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)

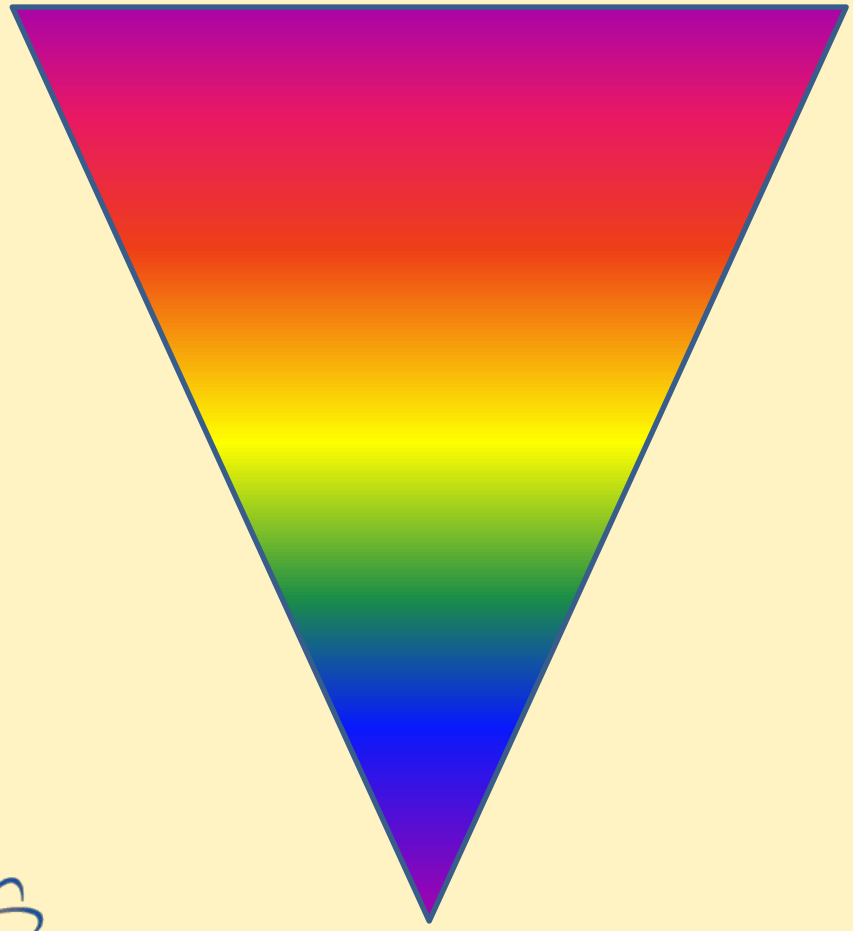
Basic Radioactive Material Transportation #30462

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

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

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

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

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

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

Los Alamos NATIONAL LABORATORY EST.1943
Operated by Los Alamos National Security, LLC for the NNSA
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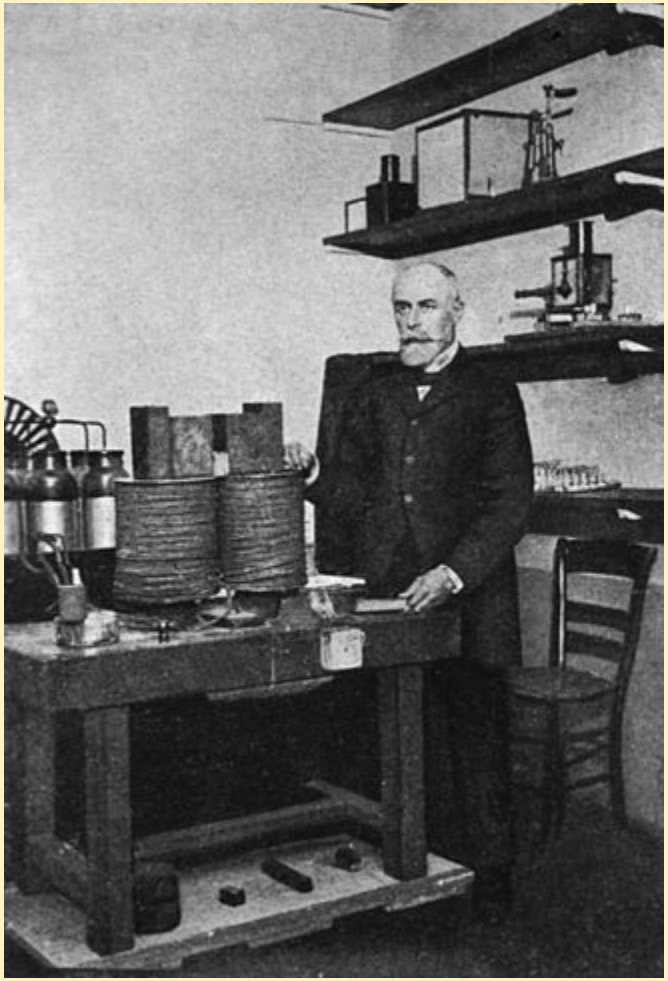
NNSA

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 Ci/TBq = (#) Tbq

Conversion between US Customary & SI Units of Activity

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)

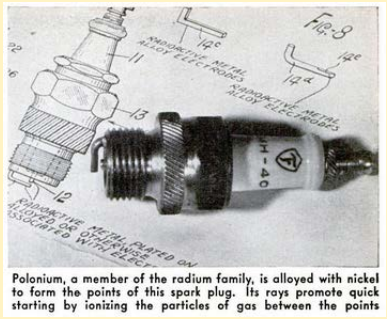
Definition of Class 7 Radioactive Material

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 Material

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.

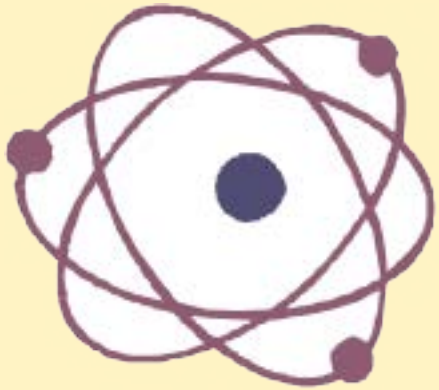
(Answers on page 36)

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.



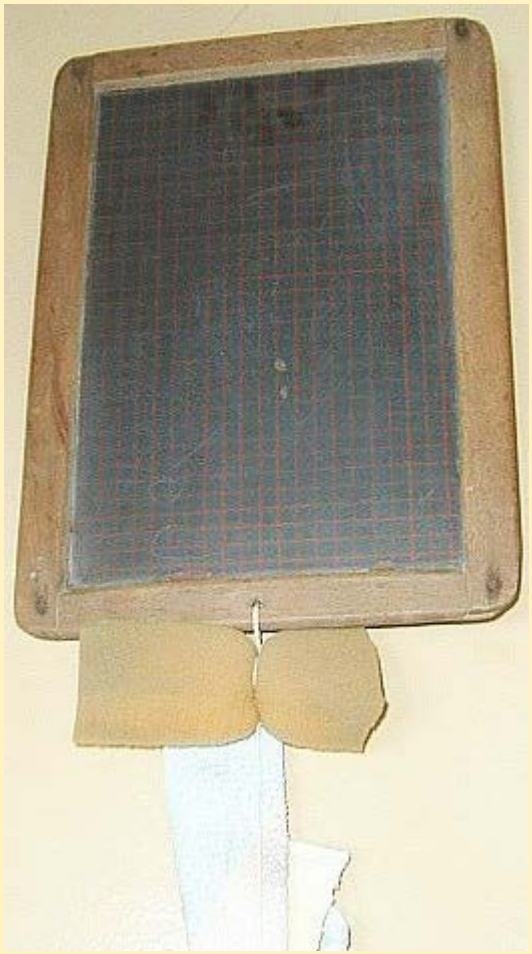
49 CFR 173.436

§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 Material—cont.

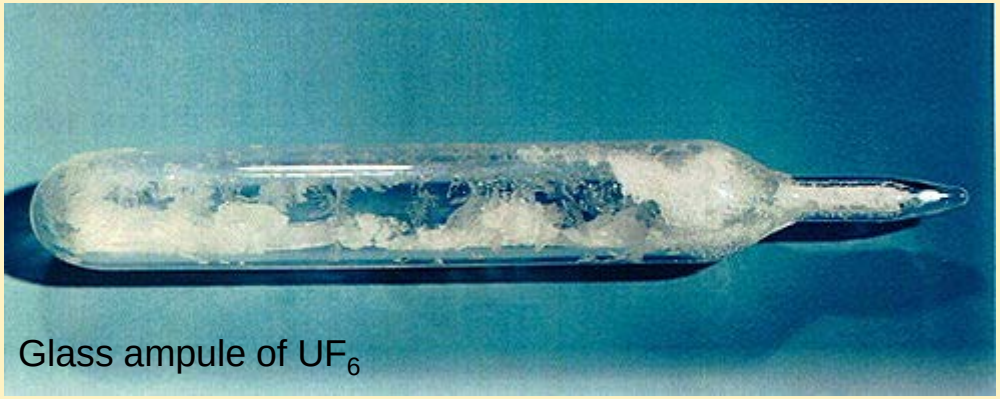
Special-form, class 7 (radioactive) material

- 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).

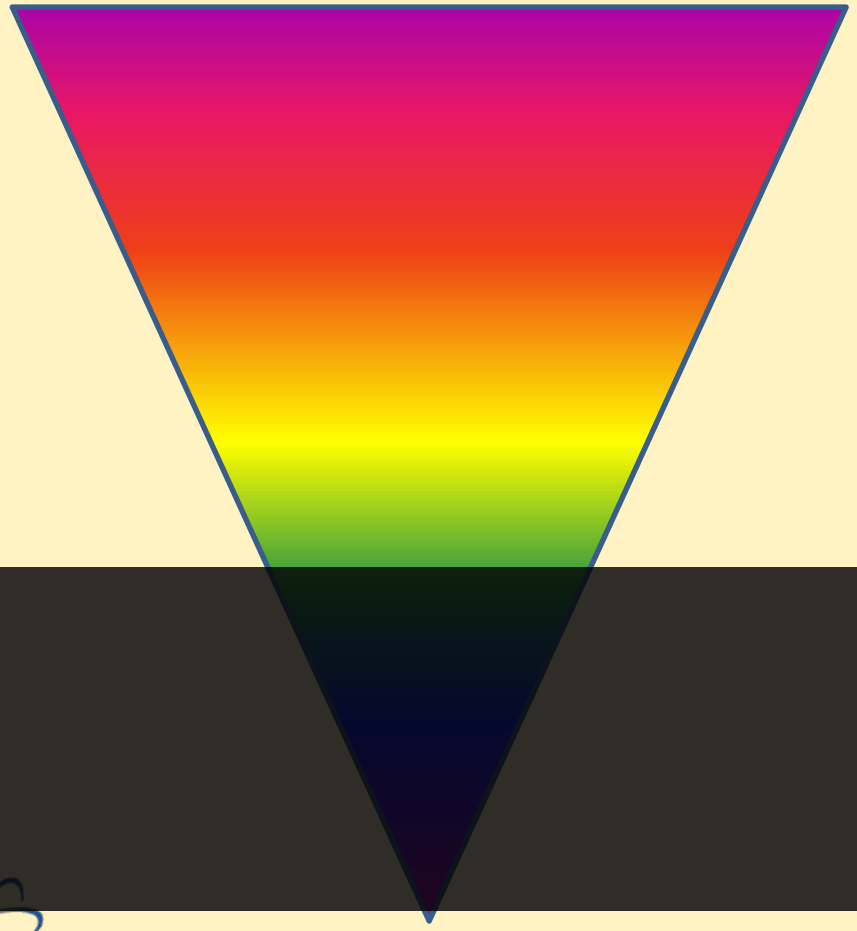
Shipping Quantities for Radioactive Material—cont.

Normal-form, class 7 (radioactive) material

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



Shipping Quantities for Radioactive Material—cont.



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

Shipping Quantities for Radioactive Material—A Values

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.)

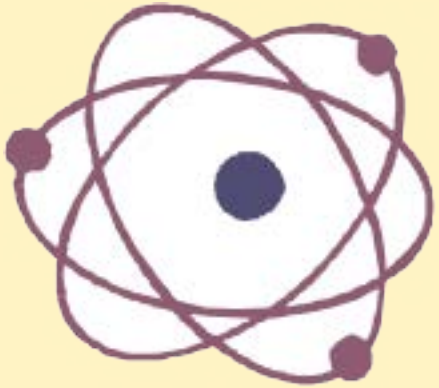
Shipping Quantities for Radioactive Material—cont.

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)

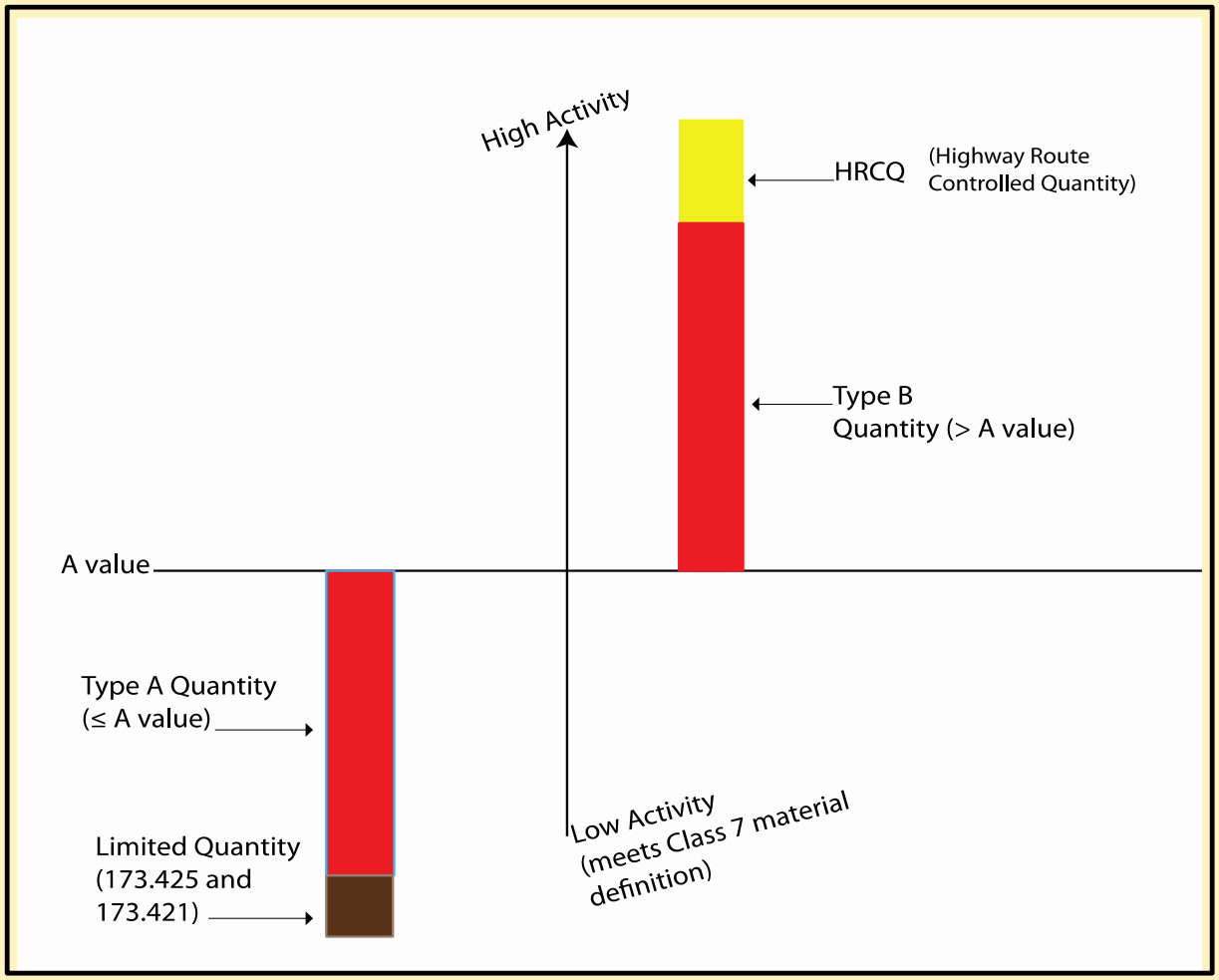
Shipping Quantities for Radioactive Material—cont.

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



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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.

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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).

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).

Shipping Categories for Radioactive Material—cont.

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.

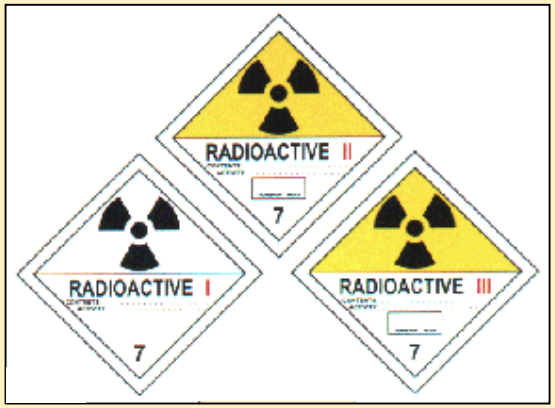
Proper Shipping Names for Radioactive Material—cont.

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.

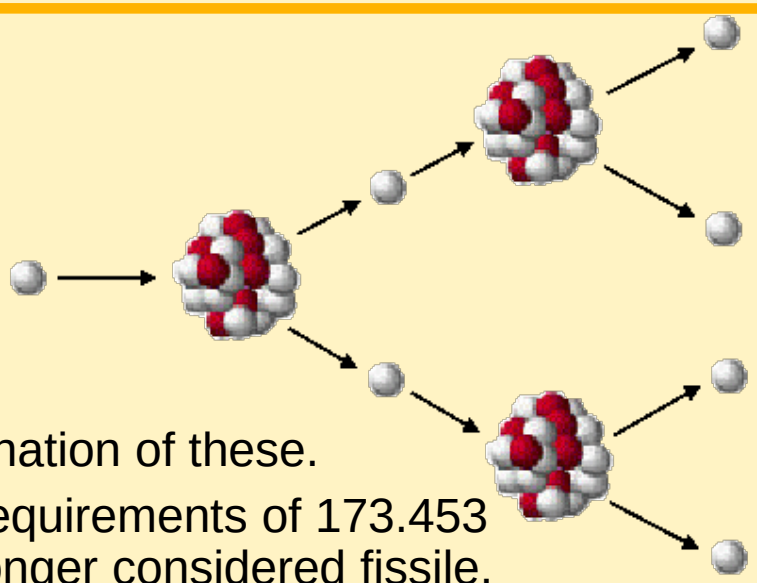


- PSNs for **fissile** material contain the word "fissile"; nonfissile or fissile-excepted PSNs are identified by the words *"non-fissile or fissile excepted"* in italics.
- PSNs applicable to **special-form** material contain the words "special form"; nonspecial-form material PSNs are identified by 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 Material—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 4×10^4 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters, or 4×10^3 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 4×10^4 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters or 4×10^3 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 x 10^5 Bq/cm^2 for beta and gamma and low-toxicity alpha emitters, or 8 x 10^4 Bq/cm^2 for all other alpha emitters; and

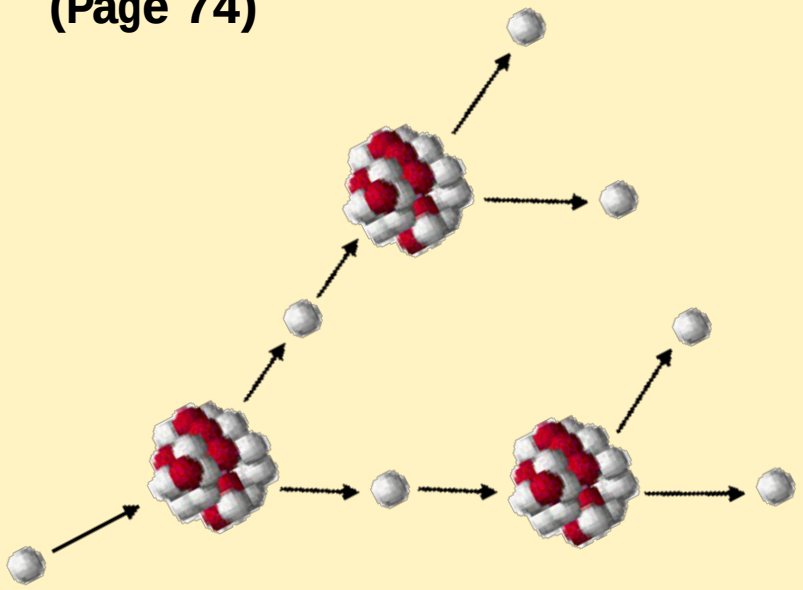
- the nonfixed contamination, plus the fixed contamination on the inaccessible surface, averaged over 300 cm2 (or the area of the surface if <300 cm2), does not exceed 8 x 105 Bq/cm2 for beta and gamma and low-toxicity alpha emitters or 8 x 10^4 Bq/cm^2 for all other alpha emitters.

Additional requirements are stipulated in 49 CFR 173.427.

Proper Shipping Names for Radioactive Material—cont.

Perform Self-Assessment in Student Manual

(Page 74)



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

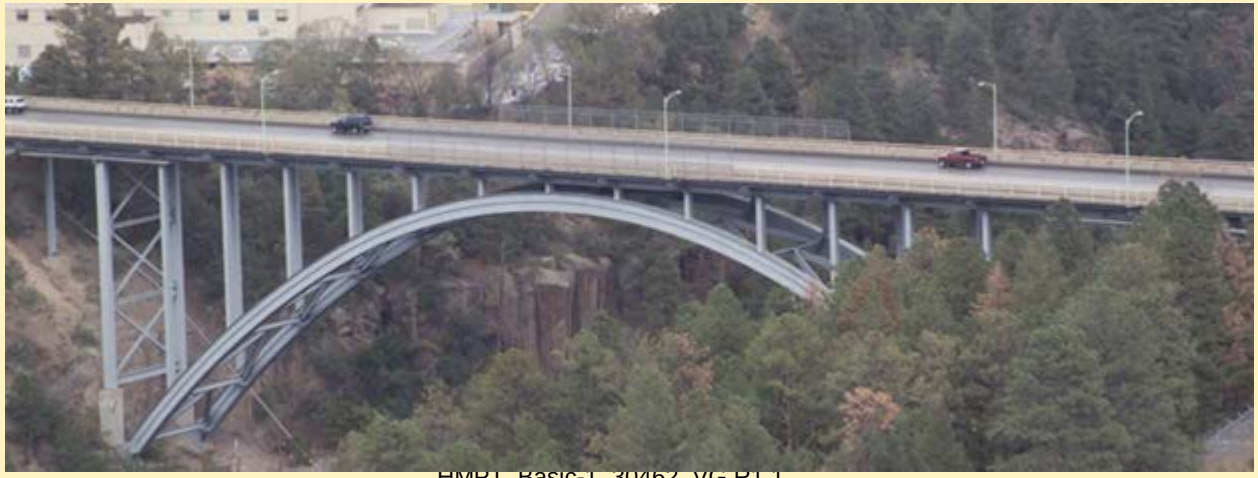
- If a radionuclide is not listed in Table 2, it is automatically assigned an RQ value of 0.037 TBq (1 Ci).
- Whenever the RQs listed in Table 1 and Table 2 conflict, the lower RQ shall apply.

Requirements for Hazardous Substances – cont.

Activity 11
(page 81)

Determination of RQ Values for Single, Known Radionuclides and

Perform Self-Assessment in Student Manual
(page 82)



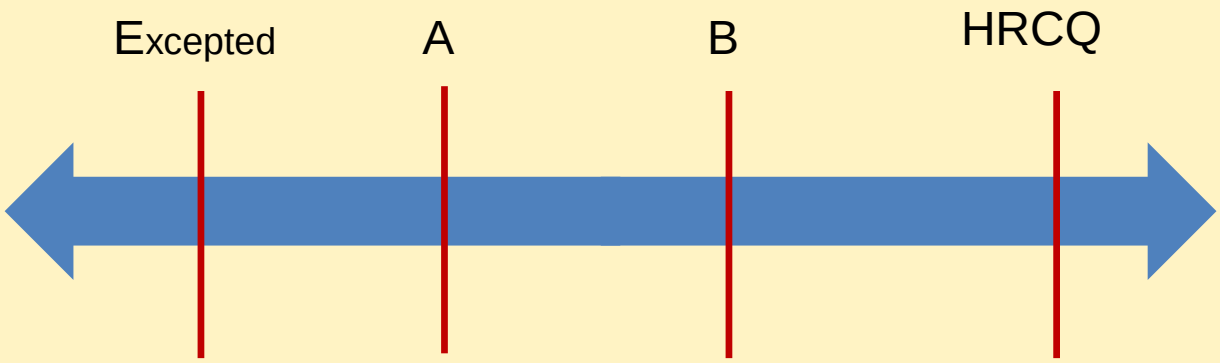
Packaging Requirements for Radioactive Material

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
- Limited-quantity material
- 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

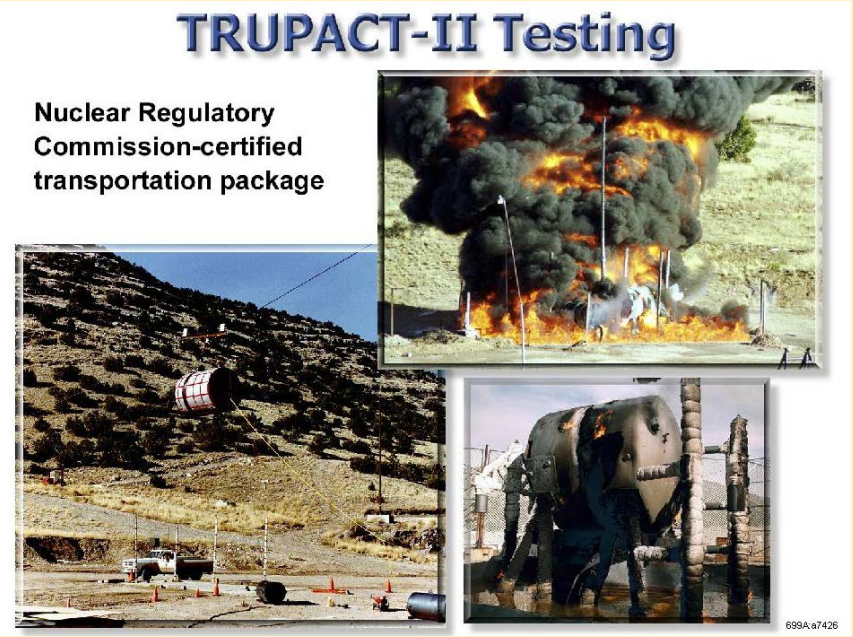
- Fissile material
- Fissile materials, excepted quantities
- Special-form material
- “Specifically listed” radioactive material proper shipping names

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
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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 Material—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 104)

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

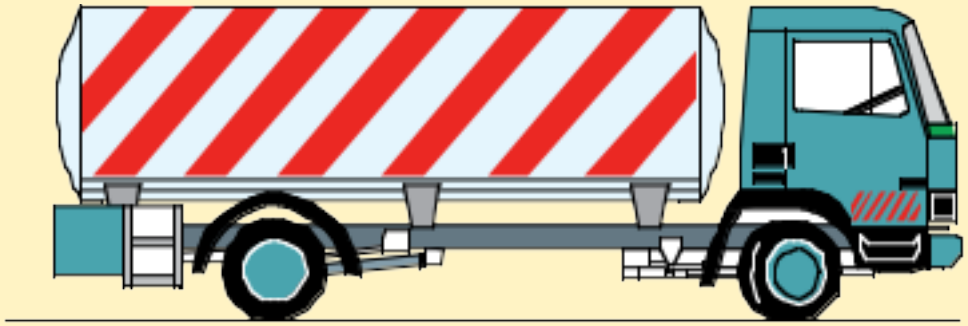
Additional Labeling Requirements

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

Labeling Requirements for Radioactive Material

Perform Self-Assessment in Student Manual

(Page 112)



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 Material—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 121)

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 125)

Additional Transportation Requirements and Limitations

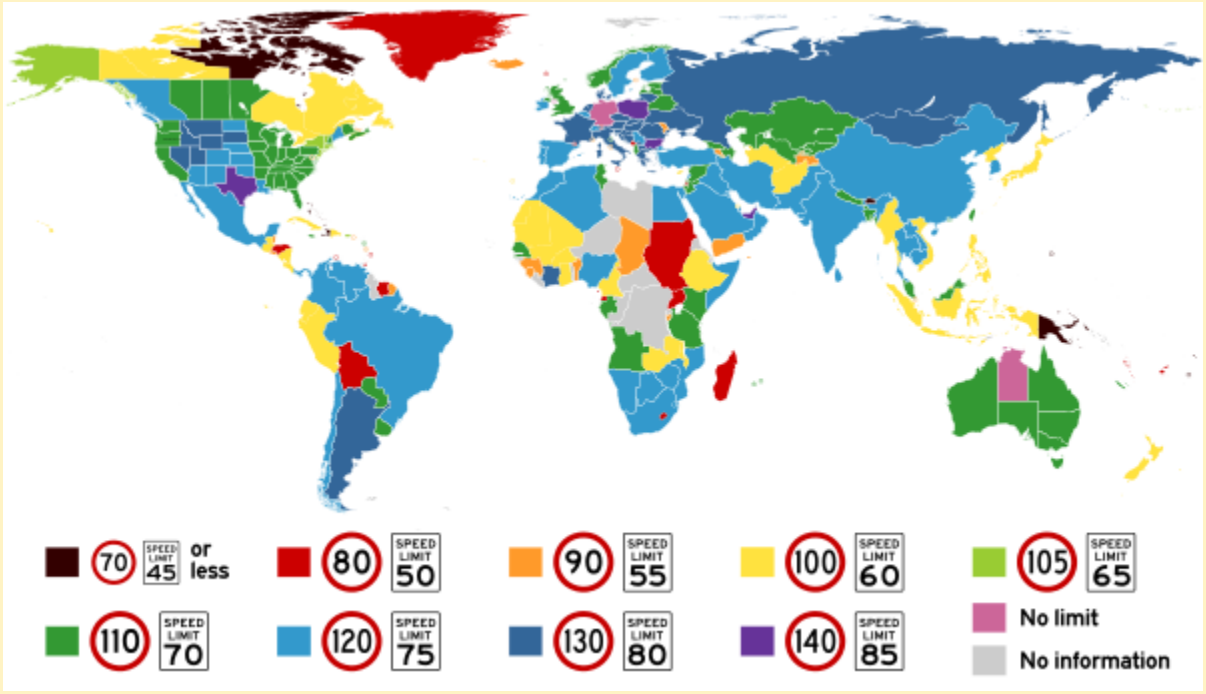
Section Objectives

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 127)



Additional Transportation Requirements and Limitations – cont.

Package Radiation Level and Transport Index Limits

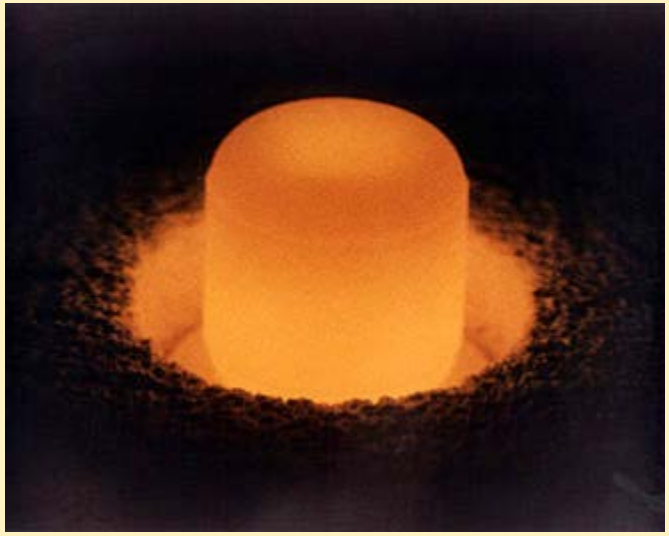
(See Student Manual, page 128)

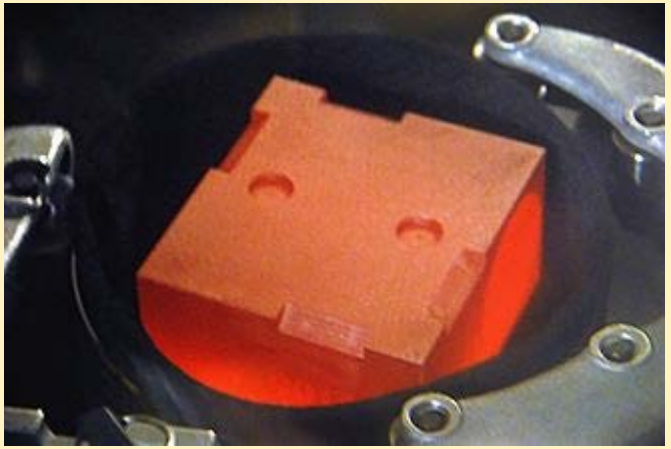
- Radiation level cannot exceed 2 mSv/h (200 mrem/h) on any package surface
- TI cannot exceed 10

Additional Transportation Requirements and Limitations – cont.

Package Thermal Limits

(See Student Manual, page 128)





Additional Transportation Requirements and Limitations – cont.

Package Surface Contamination Limits

Maximum Permissible Limits			
Contaminant	**Bq/cm^2**	**µci/cm^2**	**dpm/cm^2**
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 130)

- 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 133)

HMPT: Basic Radioactive Material
Course 30462

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