UNIT 3
HAZARDOUS MATERIAL CLASSIFICATION and DETERMINATION

U.S. Nuclear Regulatory Commission and Agreement States

"Transportation of Radioactive Materials"
NRC Course H-308

OBJECTIVES

- Define hazardous material, hazardous substance, and hazardous waste.
- Determine if a substance meets the definition of a hazardous material, hazardous substance, and/or hazardous waste.
- Identify the determining criteria for the regulation of Class 7 radioactive material.
- Determine if material is subject to transport regulations.

DEFINITION

- **Hazardous Material (§171.8)** - A substance or material capable of posing an unreasonable risk to health, safety, or property when transported in commerce. The term *includes*:
  - Hazardous substances;
  - Hazardous waste;
  - Marine pollutants;
  - Elevated temperature materials;
  - Materials designated as hazardous in the hazmat table; and
  - Materials that meet the defining criteria for hazard classes and divisions in Part 173 of Subchapter C.

IS IT HAZARDOUS MATERIAL?

Hazardous Substance?
Hazardous Waste?
Marine pollutant?
Elevated Temperature Material?

Materials designated as hazardous in the HMR (§172.101)

Materials that meet a hazard Class/Division? Defining criteria in Part 173

DEFINITION

§171.8

- ***Hazardous Substance:*** mixtures and solutions that are:
  - Listed in Appendix A to §172.101
  - Quantities ≥ Reportable Quantity (RQ) of Table 2, App A, §172.101
  - When in mixture or solution:
    - Radionuclides: conforms to App A, §172.101, paragraph 7
    - Non radionculides: concentrations ≥ RQ for that material of table in §171.8

HAZARDOUS SUBSTANCE DETERMINATION

§172.101 Table 1 to Appendix A – Hazardous Substances Other Than Radionuclides

Hazardous substance	Reportable quantity (RQ) pounds (kilograms)
A2213	5000 (2270)
Acenaphtene	100 (45.4)
Acenaphtaylene	5000 (2270)
Acetaldehyde	1000 (454)
Acetaldehyde, chloro	1000 (454)
Acetaldehyde, trichloro	5000 (2270)
Acetamide	100 (45.4)

Note: There are no radionuclides listed in Table 1 to Appendix A of §172.101. Listings of radionuclides are found in Table 2 to Appendix A

TABLE 2 TO APPENDIX A

§172.101

Table 2 to Appendix A - Radionuclides

(1) Radionuclides	(2) Atomic Number	(3) Reportable Quantity (RQ) Ci (TBq)
Actinium-224	89	100 (3.7)
Actinium-225	89	1 (.037)
Actinium-226	89	10 (.37)
Actinium-227	89	0.001 (.000037)
Actinium-228	89	10 (.37)
Aluminum-26	13	10 (.37)
Americium-237	95	1000 (37)
RADIONUCLIDES $ †		1 (.037)

† The RQ of one curie applies to all radionuclides not otherwise listed. Whenever the RQs in TABLE 1 – HAZARDOUS SUBSTANCES OTHER THAN RADIONUCLIDES and this table conflict, the lowest RQ shall apply. For example, uranyl acetate and uranyl nitrate have RQs shown in TABLE 1 of 100 pounds, equivalent to about one-tenth the RQ level for uranium-238 in this table.

DEFINITION

§171.8

- ***Hazardous Waste (for the purpose of 49 CFR):*** Any material that is subject to the Hazardous Waste Manifest requirements of the EPA. As specified by 40 CFR Part 262 (40 CFR §262.11)

HAZARDOUS WASTE DETERMINATION

- Determine waste is a hazardous waste:
  - Is waste excluded from regulation (40 CFR 261.4)
  - Is waste listed as a hazardous waste in Subpart D of 40 CFR Part 261
  - If the waste is not listed in Subpart D of 40 CFR Part 261, the generator must then determine whether the waste is identified in Subpart C of 40 CFR Part 261

DEFINITION

§171.8

- ***Marine Pollutant:*** material which is listed in Appendix B to §172.101 when in solution or mixture of one or more pollutants.

- Packaged:
  - ≥ 10% by weight of the solution/mixture for materials listed in App B **OR**
  - ≥ 1% by weight of the solution/mixture as listed as severe marine pollutants

§172.101 Appendix B – List of Marine Pollutants

SMP (1)	Marine Pollutant (2)
	Acetone cyanohydrin, stabilized
	Actetyline tetrabromide
	Actetyline tetrachloride
	Acraldehyde inhibited
	Acrolein, inhibited
	Acrylic aldehyde, inhibited
	Alcohol, C-12-C-16 poly(1-6) ethoxylate

SMP = Severe Marine Pollutants

MARINE POLLUTANTS

- ***Marine Pollutants:*** Except as provided in §171.4(c), no person may offer for transportation or transport a marine pollutant in intrastate or interstate commerce except in accordance with requirements of Subchapter C. [§171.4 (a)]

- ***EXCEPTION***… does not apply to non-bulk packagings transported by motor vehicle, rail or aircraft unless all or part of the transportation is by vessel [§171.4(c)]

HAZARDOUS MATERIAL CLASSES

§173.2

Class No.	Division No. (if any)	Name of class or division	49 CFR Reference for definitions
None	….	Forbidden materials	173.21
None	….	Forbidden explosives	173.54
1	1.1	Explosives (with a mass explosion hazard)	173.50
1	1.2	Explosives (with a mass projection hazard)	173.50
1	1.3	Explosives (with predominantly a fire hazard)	173.50
1	1.4	Explosives (with no significant blast hazard)	173.50
1	1.5	Very insensitive explosives; blasting agents	173.50
1	1.6	Extremely insensitive detonating substances	173.50
2	2.1	Flammable gas	173.115
2	2.2	Non-flammable compressed gas	173.115
2	2.3	Poisonous gas	173.115
3	….	Flammable and combustible liquid	173.120

EXEMPTION LIMITS

CLASS 7 RADIOACTIVE MATERIAL

- Based on Exempt Material ***and*** Exempt Consignment
  - Isotope specific
  - Assumes uniform distribution
- Based on Level of Contamination
  - External contamination at or above (averaged over 300 cm^2):
    0.4 Bq/cm^2 beta/gamma and low toxicity alpha
    0.04 Bq/cm^2 other alpha
  - Application of Exempt Consignment unknown

49 CFR 173.436

EXEMPTION ACTIVITY LIMITS

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

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)
Cs-129	Cesium (55)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cs-131		1.0×10^{-3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Cs-132		1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Cs-134		1.0×10^{1}	2.7×10^{-2}	1.0×10^{4}	2.7×10^{-7}
Cs-134^{m}		1.1×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Cs-135		1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Cs-136		1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Cs-137[b]		1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}

EXAMPLE 1

H-3 5.1 GBq 5,000 g

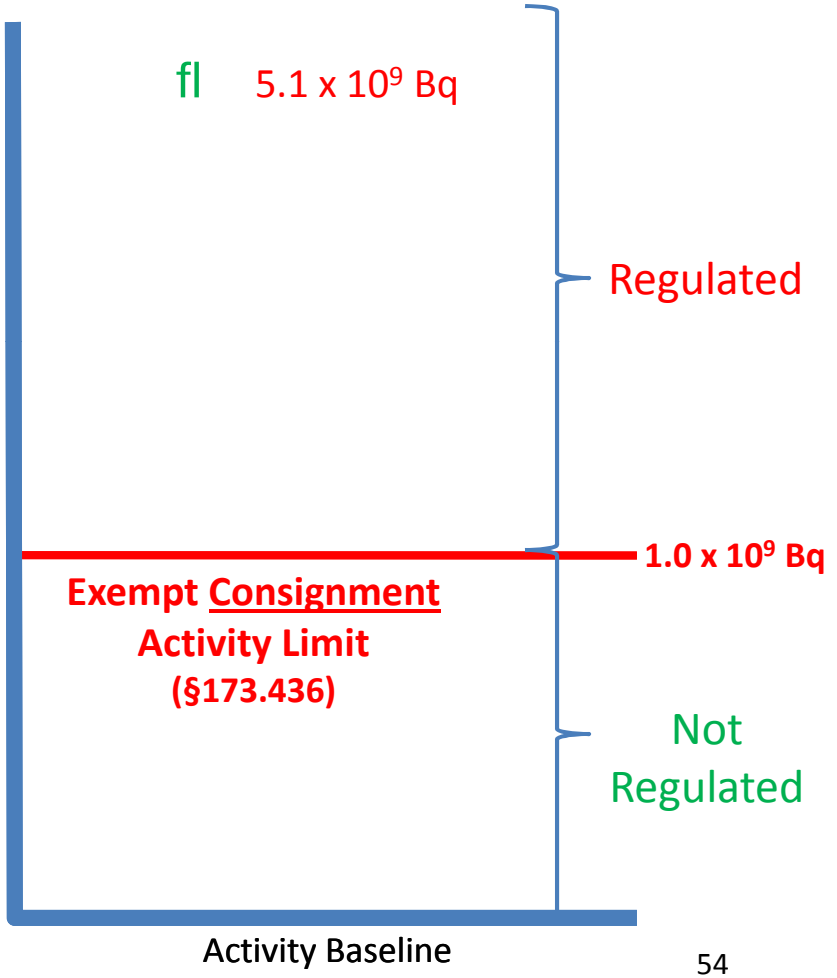
EXEMPT CONSIGNMENT

1. Convert: 5.1 GBq = 5.1 x 10^9 Bq

2. Exempt Consignment Activity Limit (§173.436)
   H-3 = 1.0 x 10^9 Bq

3. Compare total activity of consignment vs. exempt consignment activity limit
   5.1 x 10^9 Bq > 1.0 x 10^9 Bq

Activity exceeds Exempt Consignment Activity Limit, therefore: ***REGULATED***



EXAMPLE 1

H-3 5.1 GBq 5,000 g

EXEMPT MATERIAL

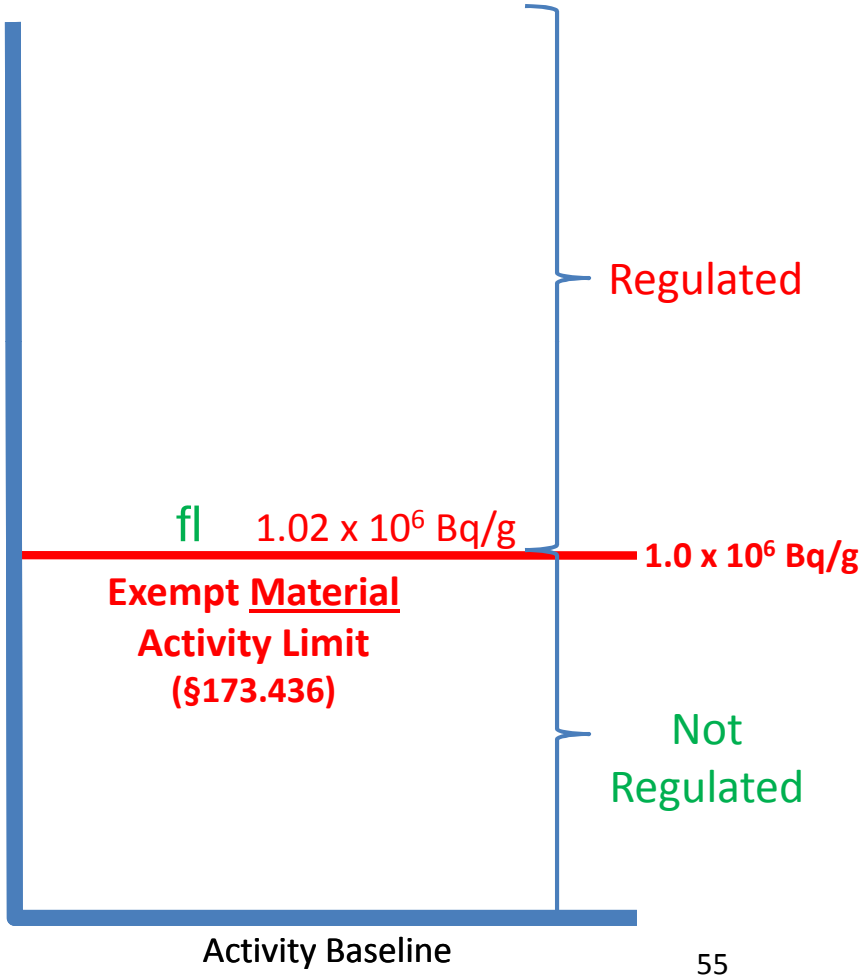
1. Convert: 5.1 GBq = 5.1 x 10^9 Bq

2. Determine activity/gram:
   5.1 x 10^9 Bq ÷ 5000 g = 1.02 x 10^6 Bq/g

3. Exempt Material Activity Limit (§173.436):
   H-3 = 1 x 10^6 Bq/g

4. Compare activity per gram of material vs. exempt material activity limit
   1.02 x 10^6 Bq/g > 1 x 10^6 Bq/g

Activity exceeds Exempt Material Activity Limit, therefore: ***REGULATED***



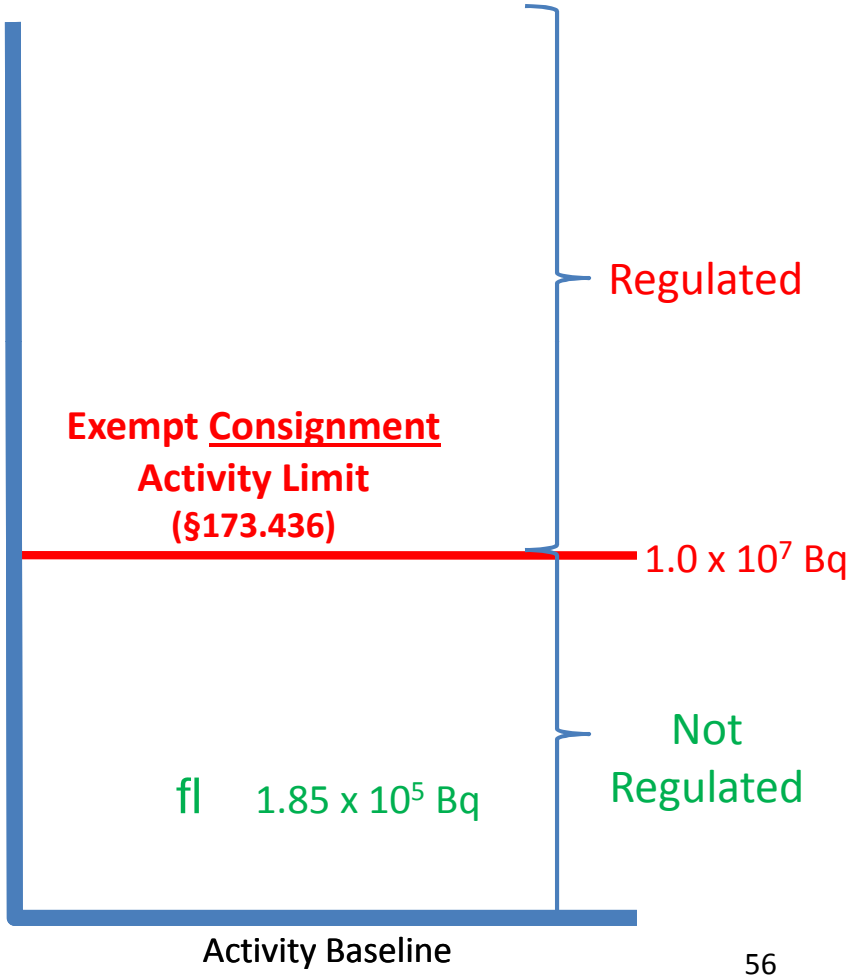
EXAMPLE 2

Pm-145 0.185 MBq 50 g

EXEMPT CONSIGNMENT

1. Convert: 0.185 MBq = 1.85×10^5 Bq
2. Exempt Consignment Activity Limit (§173.436):
   Pm-147 = 1×10^7 Bq
3. Compare activity of consignment
   vs. exempt consignment activity limit
   1.85×10^5 Bq < 1.0×10^7 Bq

Does not exceed Exempt Consignment Activity Limit, therefore: ***NOT REGULATED***



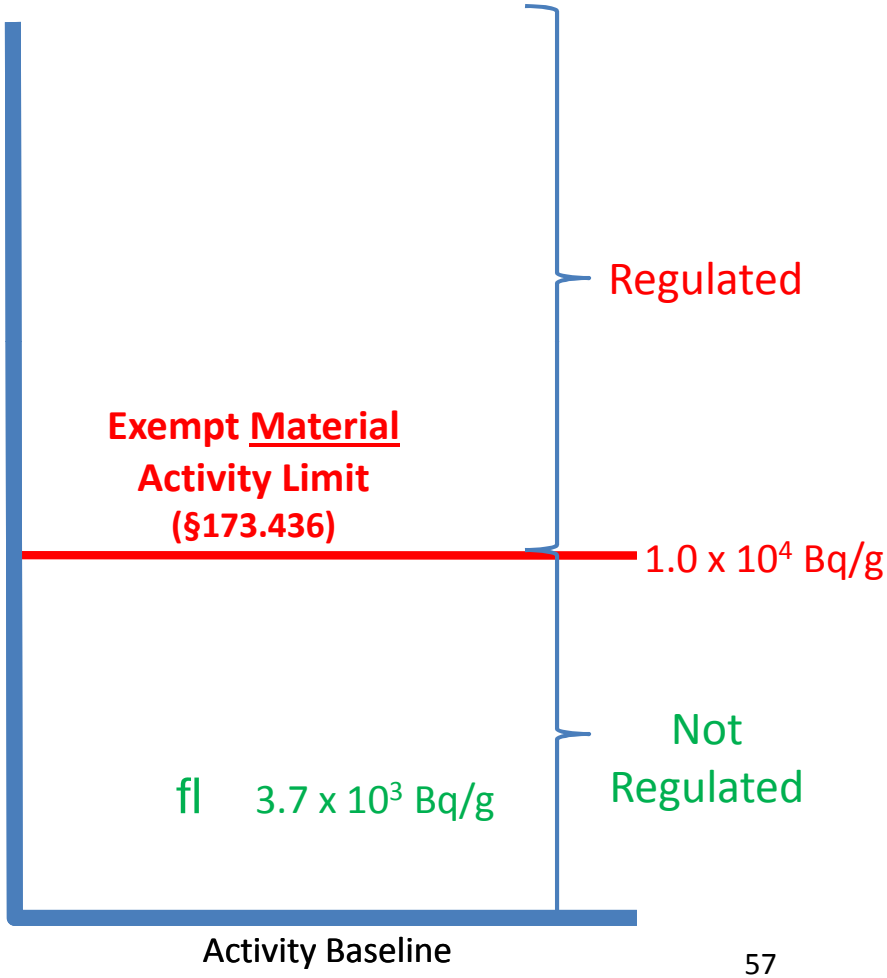
EXAMPLE 2

Pm-145 0.185 MBq 50 g

EXEMPT MATERIAL

1. Convert: 0.185 MBq = 1.85×10^5 Bq
2. Determine activity/gram:
   1.85×10^5 Bq ÷ 50g = 3.7×10^3 Bq/g
3. Exempt Material Activity Limit (§173.436):
   Pm-147 = 1×10^4 Bq/g
4. Compare activity per gram of material vs. exempt material activity limit
   3.7×10^3 Bq/g < 1.0×10^4 Bq/g

Does not exceed Exempt Consignment Activity Limit, therefore: ***NOT REGULATED***



UNLISTED or UNKNOWN

Table 8, General Exemption Values, §173.433(h)

Radioactive contents	**Activity concentration for exempt material**		**Activity limits for exempt consignment**	
	(Bq/g)	(Ci/g)	(Bq)	(Ci)
1. Only beta or gamma emitting nuclides are known to be present	1×10^{1}	2.7×10^{-10}	1×10^{4}	2.7×10^{-7}
2. Only alpha emitting nuclides are known to be present	1×10^{-1}	2.7×10^{-12}	1×10^{3}	2.7×10^{-8}
3. No relevant data available	1×10^{-1}	2.7×10^{-12}	1×10^{3}	2.7×10^{-8}

§173.433(b): For individual radionuclides not listed in §173.435 or §173.436

UNITY SUM ACTIVITY LIMITS

MIXTURES OF RADIONUCLIDES

EXEMPT CONSIGNMENT

$$\frac{R_1}{AC} + \frac{R_2}{AC} + \frac{R_3}{AC}$$

> 1 : REGULATED

≤ 1 : *NOT* REGULATED

$R_{1/2/3}$ = Activity/radionuclide

AC = Exempt Limit/consignment (Bq)

AND…

UNITY SUM ACTIVITY LIMITS

MIXTURES OF RADIONUCLIDES

EXEMPT MATERIAL/PACKAGE

$$\frac{R_1}{\frac{NM(g)}{AL}} + \frac{R_2}{\frac{NM(g)}{AL}} + \frac{R_3}{\frac{NM(g)}{AL}}$$

> 1 : REGULATED

≤ 1 : *NOT* REGULATED

$R_{1/2/3}$ = Activity/radionuclide

NM(g) = Net Mass in grams

AL = Exempt Material limit/pkg (Bq/g)

EXEMPT CONSIGNMENT

MULTIPLE ISOTOPES (SOLID)

EXAMPLE: Activity: (NM = 4,000 g)

Am-241	R_1	2.06 kBq (2,060 Bq)
Cs-137	R_2	1.07 kBq (1,070 Bq)
Sr-90	R_3	0.18 kBq (180 Bq)

Exempt Consignment Limit: (§173.436)

AC for R_1 Am-241 = 1×10^4 Bq

AC for R_2 Cs-137 = 1×10^4 Bq

AC for R_3 Sr-90 = 1×10^4 Bq

Ratios:

$$\text{Am-241} = \frac{2{,}060 \text{ Bq}}{10{,}000 \text{ Bq}} = 0.206$$

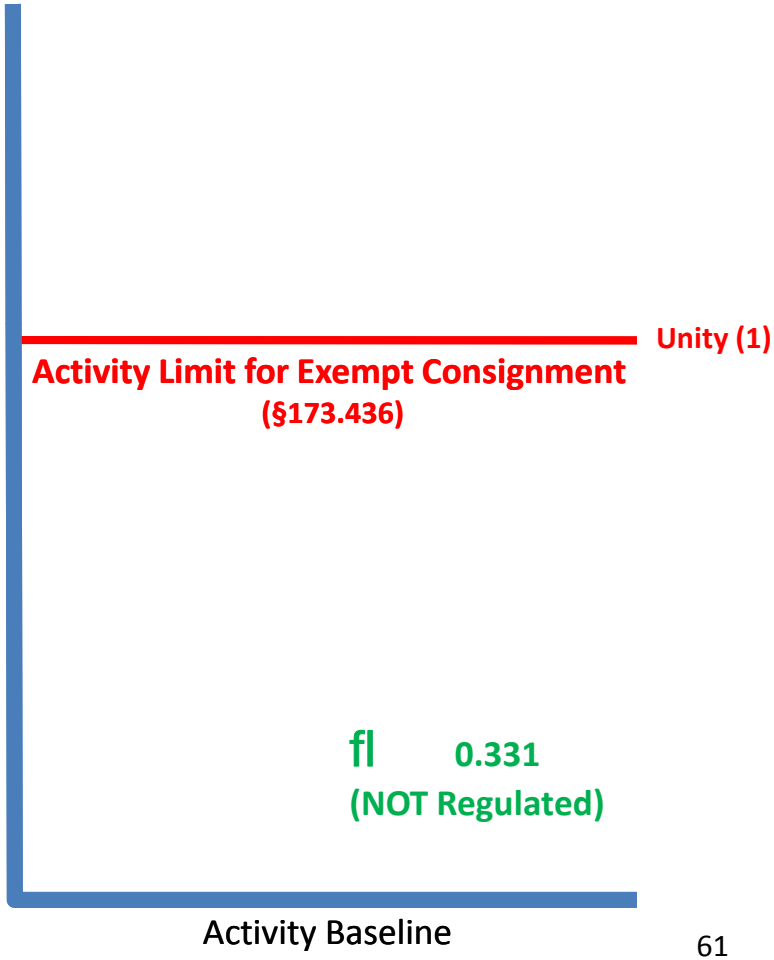
$$+$$

$$\text{Cs-137} = \frac{1{,}070 \text{ Bq}}{10{,}000 \text{ Bq}} = 0.107$$

$$+$$

$$\text{Sr-90} = \frac{180 \text{ Bq}}{10{,}000 \text{ Bq}} = 0.018$$

Sum of Ratios 0.331



EXEMPT MATERIAL

MULTIPLE ISOTOPES (SOLID)

EXAMPLE: Activity: (NM = 4,000 g)

Am-241	R_1	2.06 kBq (2,060 Bq)
Cs-137	R_2	1.07 kBq (1,070 Bq)
Sr-90	R_3	0.18 MBq (1.8×10^5 Bq)

Exempt Material Limit (AL): (§173.436)

AL for R_1 Am-241 = 1 Bq/g

AL for R_2 Cs-137 = 1×10^1 Bq/g

AL for R_3 Sr-90 = 1×10^2 Bq/g

$$R_1 = \frac{\left(\frac{2.06x10^3\,Bq}{4{,}000g}\right)}{1.0\ \text{Bq/g}} = 0.515\ \text{Bq/g}$$

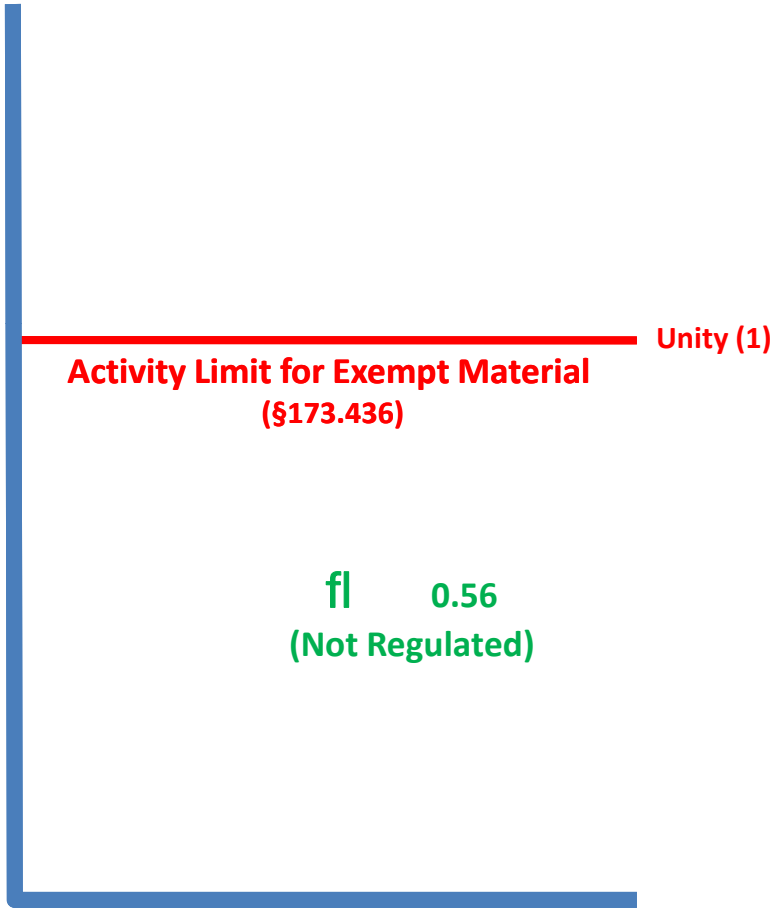
+

$$R_2 = \frac{\left(\frac{1.7x10^3\,Bq}{4{,}000g}\right)}{1.0 \times 10^1\ \text{Bq/g}} = 0.0425\ \text{Bq/g}$$

+

$$R_3 = \frac{\left(\frac{1.0x10^3\,Bq}{4{,}000g}\right)}{1.0 \times 10^2\ \text{Bq/g}} = 0.0025\ \text{Bq/g}$$

Sum of Ratios 0.56



UNITY SUM

EXEMPT MATERIAL – MULTIPLE PACKAGES

Isotope	Activity	Activity (Bq)	# of Pkgs/ Consignment	Activity Limit Exempt Consignment (§173.436)
Co-60	370 MBq	3.7×10^8 Bq	2	1.0×10^5 Bq (100,000 Bq)
U-238	629 MBq	6.29×10^8 Bq	2	1.0×10^4 Bq (10,000 Bq)
Cs-137	925 MBq	9.25×10^8 Bq	2	1.0×10^4 Bq (10,000 Bq)

Co-60 = 3.7×10^8 Bq x 2 pkgs = 7.4×10^8 Bq

$$\frac{7.4x10^8\,Bq}{1x10^5\,Bq} = 7.4x10^3$$

+

U-238 = 6.29×10^8 Bq x 2 pkgs = 1.25×10^9 Bq

$$\frac{1.25x10^9\,Bq}{1x10^4\,Bq} = 1.25x10^5$$

+

Cs-137 = 9.25×10^8 Bq x 2 pkgs = 1.85×10^9 Bq

$$\frac{1.85x10^9\,Bq}{1x10^4\,Bq} = 1.85x10^5$$

REGULATED

UNITY SUM CONCENTRATION

EXEMPT MATERIAL – MULTIPLE PACKAGES

In 4,000 g

Isotope	Activity	Activity (Bq)	# of Pkgs/ Consignment	Activity Concentration Exempt Material (§173.436)
Co-60	370 MBq	3.7×10^8 Bq	2	1.0×10^1 Bq/g (10 Bq/g)
U-238	629 MBq	6.29×10^8 Bq	2	1.0×10^1 Bq/g (10 Bq/g)
Cs-137	925 MBq	9.25×10^8 Bq	2	1.0×10^1 Bq/g (10 Bq/g)

$$\left(\frac{3.7x10^8\,Bq}{4{,}000g}\right) + \left(\frac{6.29x10^8\,Bq}{4{,}000g}\right) + \left(\frac{9.25x10^8\,Bq}{4{,}000g}\right)$$

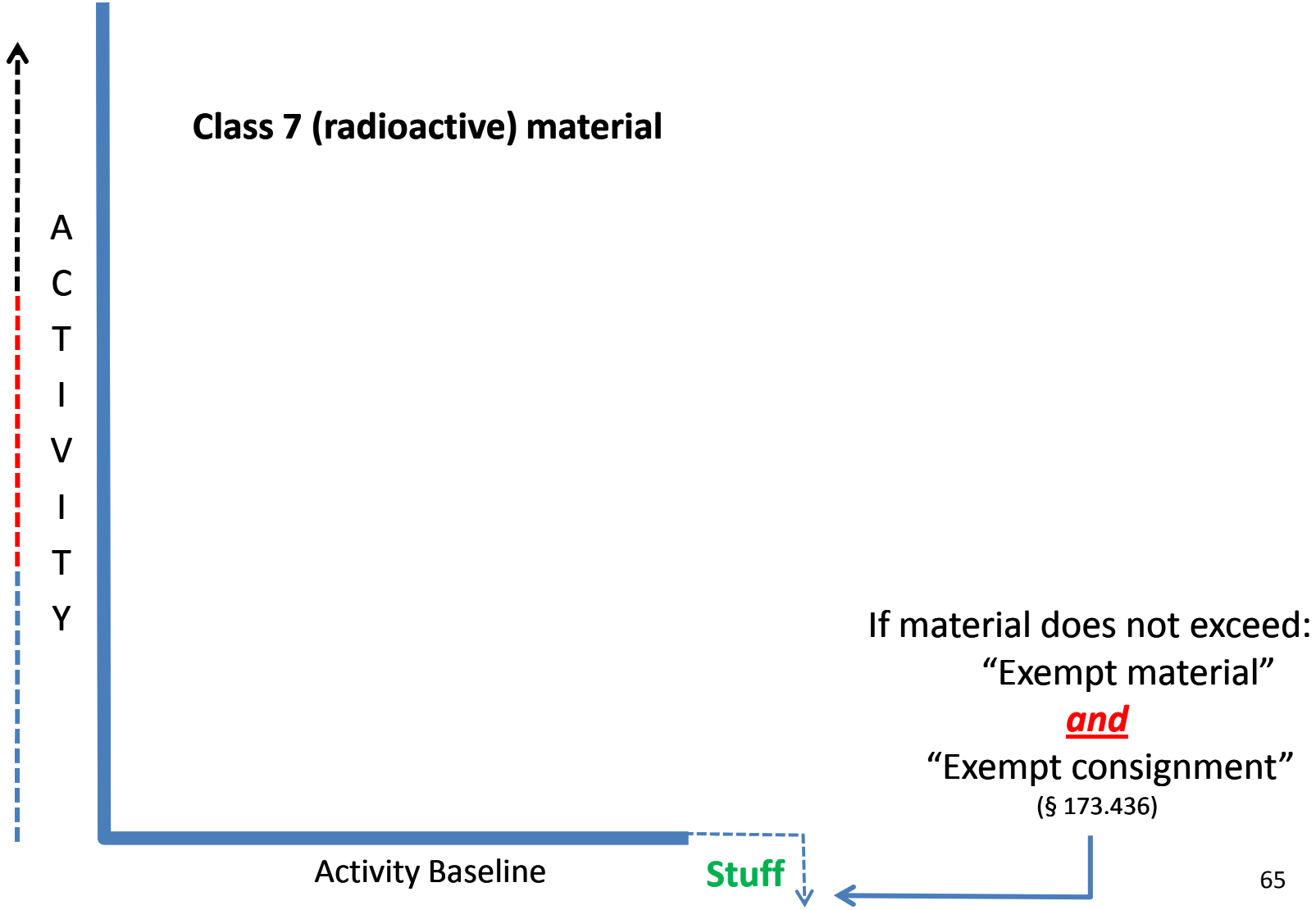
$$= \frac{9.25 \times 10^4 \text{ Bq/g}}{1.0 \times 10^1 \text{ Bq/g}} + \frac{1.57 \times 10^5 \text{ Bq/g}}{1.0 \times 10^1 \text{ Bq/g}} + \frac{2.31 \times 10^5 \text{ Bq/g}}{1.0 \times 10^1 \text{ Bq/g}}$$

$$= 9.25 \times 10^3 \quad = 1.57 \times 10^4 \quad = 2.31 \times 10^4$$

Total: 48,050

REGULATED

IS IT REGULATED?



SUMMARY

- Classification of hazardous material
  - Hazardous Substance
  - Hazardous Waste
  - Marine Pollutant
- Materials designated as hazardous in the HMT
- Determination of hazard class – defining criteria.
- Exempt Material and Exempt Consignment
- Calculations
  - Single, Multiple and Unknown radionuclides