

UNIT 4

ACTIVITY LIMITS



U.S. Nuclear Regulatory Commission and Agreement States

“Transportation of Radioactive Materials”

NRC Course H-308



OBJECTIVES

- Define Normal Form and Special Form radioactive material.
- Determine type activity limits for a given radioisotope based on its activity and form.



BASIC PRINCIPLE for RADIOACTIVE MATERIAL TRANSPORT

A L A R A

As Low As Reasonably Achievable



BASIC PRINCIPLE for RADIOACTIVE MATERIAL TRANSPORT

**LIMIT THE ACTIVITY OF THE RADIOACTIVE
CONTENTS PER PACKAGE BASED ON THE
HAZARD THE PARTICULAR MATERIAL
PRESENTS IN TRANSPORT**



FACTORS TO CONSIDER

- *Content limit* is the activity limit of the radioactive material imposed by the Regulations, based on the definition of the material and/or packaging.

Examples include:

- $< A_1$ or $< A_2$
- Limited Quantity
- Empty Package



FACTORS TO CONSIDER

- *Material type* includes the properties of the radioactive material which may pose additional package restrictions.

Examples include:

- Fissile material
- Definition of LSA/SCO
- Other dangerous properties of the material (e.g. pyrophoricity, caustic, etc.)



DEFINITIONS

§173.403

- 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.



DEFINITIONS

§173.403

- ***Special Form Material:*** either an indispersible solid radioactive material or a sealed capsule containing radioactive material which satisfies the following conditions:
 - It is either a single solid piece or a sealed capsule containing radioactive material that can be opened only by destroying the capsule;
 - The piece or capsule has at least one dimension not less than 5 mm (0.2 in); and
 - It satisfies the test requirements of §173.469.
- ***Normal Form Material:*** material which has not been demonstrated to qualify as “special form Class 7 (radioactive) material.”



PACKAGE ACTIVITY LIMITS

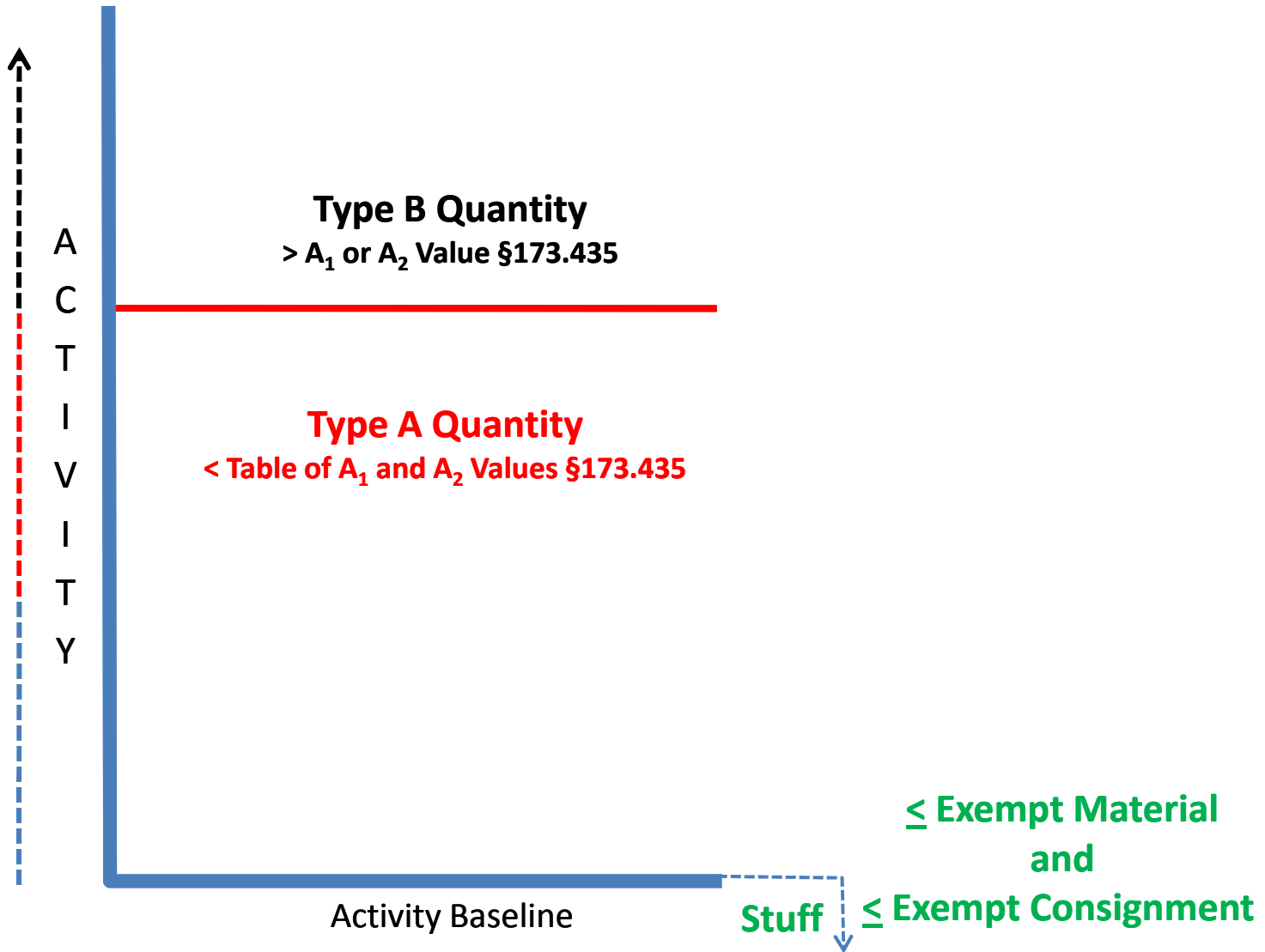




TABLE OF A_1 and A_2 VALUES

§173.435

10 CFR §71, Appendix A, Table A-1
 49 CFR §173.435 Table of A_1 and A_2 values for radionuclides

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^{-3}	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^{-3}	1.4×10^1	8.2×10^4	2.2×10^4
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-108 ^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

- Alphabetically by symbol
- A_1 – max. activity of Special Form radioactive permitted in a Type A package (TBq & Ci)
- A_2 – max. activity of Normal Form radioactive material permitted in a Type A package (TBq & Ci)
- Activity to gram values (TBq/g and Ci/g)
- Calculate own with CA approval [§173.433(b)]
- Unlisted or Unknown use Table 7, “General values for A_1 and A_2 ”, §173.433(h)



ACTIVITY LIMITS

TYPE A QUANTITIES – SINGLE & MIXTURES

- ***Single radionuclide*** - Except for LSA material and SCO:
 - Activity $\leq A_1$ value for special form [§173.431(a)]
 - Activity $\leq A_2$ value for normal form [173.431(a)]
- ***Mixtures of radionuclides*** –
 - Unity equations to where the sum of the ratios is ≤ 1 = Type A and > 1 = Type B. [§173.433(d)(3)]



TYPE A QUANTITY LIMITS

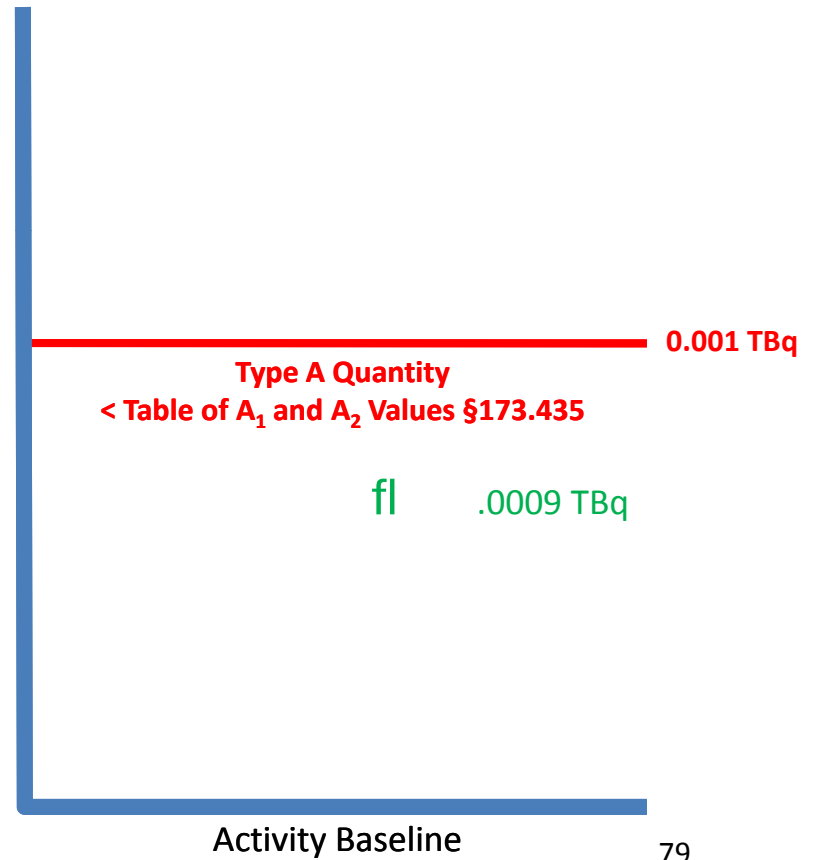
SINGLE RADIONUCLIDE

SINGLE RADIONUCLIDE
[§173.431(a)]

EXAMPLE: Am-241
Normal Form
0.0009 TBq

A_2 Value = 1×10^{-3} TBq (0.001 TBq)

Activity < Type A quantity limits
Less restrictive requirements applicable
(Type A)





TYPE A QUANTITY LIMITS

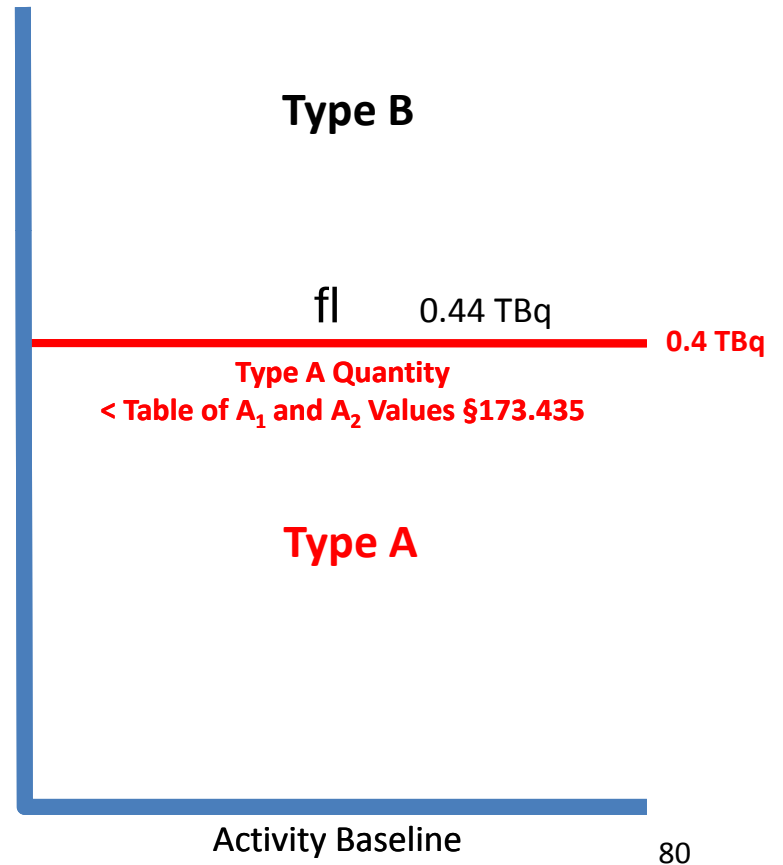
SINGLE RADIONUCLIDE

SINGLE RADIONUCLIDE
[§173.431(a)]

EXAMPLE: Co-60
Special Form
0.44 TBq

A_1 Value = 4×10^{-1} TBq (0.4 TBq)

Activity > Type A quantity limits
More restrictive requirements applicable
(Type B)





TYPE A QUANTITY LIMITS

MIXTURES OF RADIONUCLIDES

[§173.433(d)]

EXAMPLE: Am-241 0.009 TBq
Co-60 0.04 TBq
Cs-137 0.1 TBq
Special Form

A₁ Values: Am-241 = 1 x 10¹ TBq (10 TBq)
Co-60 = 4 x 10⁻¹ TBq (0.4 TBq)
Cs-137 = 2.0 TBq

Ratio of nuclides in mixture:

$$\text{Am-241} = \frac{0.009 \text{ TBq}}{10 \text{ TBq}} = 0.0009$$

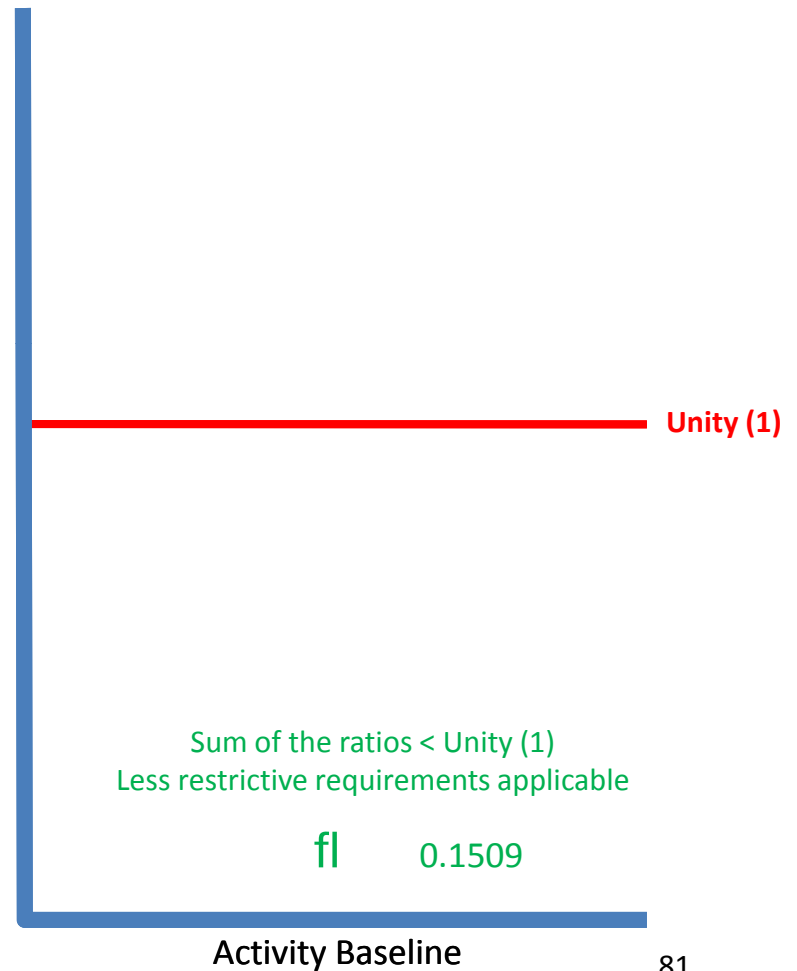
+

$$\text{Co-60} = \frac{0.04 \text{ TBq}}{0.4 \text{ TBq}} = 0.1$$

+

$$\text{Cs-137} = \frac{0.1 \text{ TBq}}{2 \text{ TBq}} = 0.05$$

TOTAL: = 0.1509





GENERAL VALUES FOR A_1 AND A_2

[§173.433(h)]

Table 7, General values for A_1 and A_2 , §173.433(h)

Radioactive contents	A_1		A_2	
	(TBq)	(Ci)	(TBq)	(Ci)
1. Only beta or gamma emitting nuclides are known to be present	1×10^{-1}	2.7×10^0	2×10^{-2}	5.4×10^{-1}
2. Only alpha emitting nuclides are known to be present	2×10^{-1}	5.4×10^0	9×10^{-5}	2.4×10^{-3}
3. No relevant data available	1×10^{-3}	2.7×10^{-2}	9×10^{-5}	2.4×10^{-3}

§ 173.433(b): For individual radionuclides which are not listed in the tables in §173.435 and § 173.436:

- (1) The radionuclide values in Table 7 or 8 may be used; or
- (2) Other basic radionuclide values may be used provided they are first approved by the Associate Administrator, or For International transport, multilateral approval is obtained from the pertinent Competent Authorities.



DEFINITIONS

(§173.403)

- ***LIMITED QUANTITY*** – material not exceeding the materials package limits specified in §173.425 (Table of activity limits – excepted quantities and articles) and conforming with requirements specified in §173.421 (Excepted packages for LQs of RAM).
- ***INSTRUMENT OR ARTICLE*** – 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 non-dispersible solid form as a component part.



ACTIVITY LIMITS

LIMITED QUANTITIES

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

1. For mixtures of radionuclides see 173.433(d)
2. These values also apply to tritium in activated luminous paint and tritium absorbed on solid carriers.



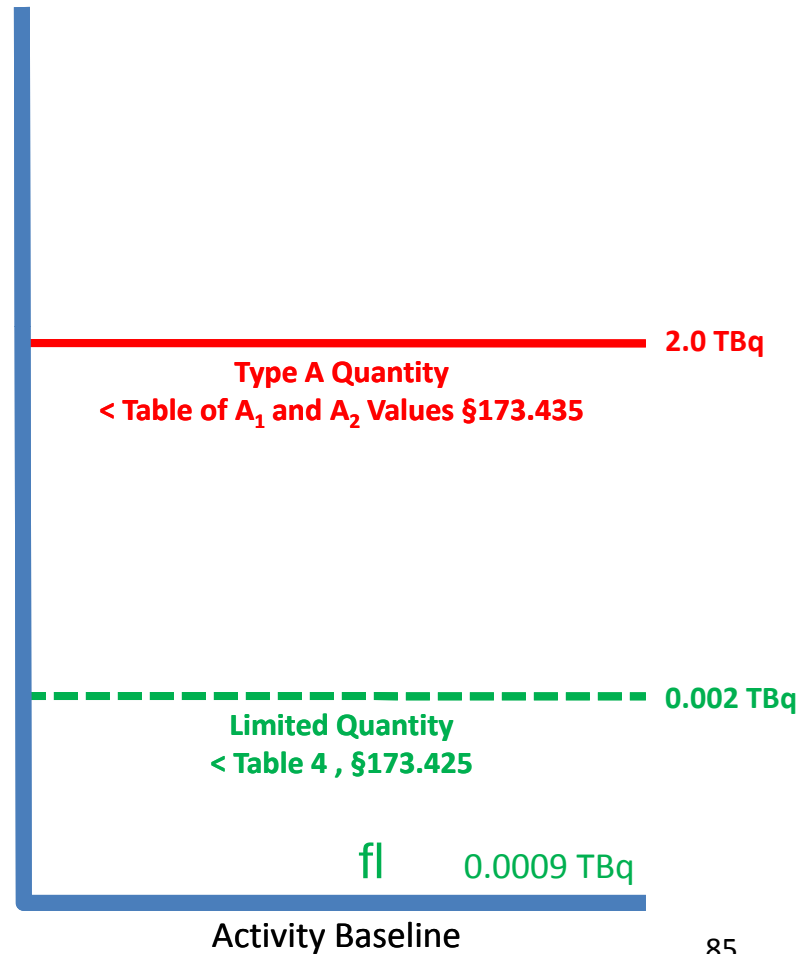
LIMITED QUANTITY

SINGLE ISOTOPE – EXAMPLE (SOLID)

EXAMPLE: Cs-137
Special Form
0.0009 TBq

A_1 Value = 2 TBq
Activity < Type A quantity limits
Less restrictive requirements applicable

LQ Value = 2.0 TBq (10^{-3})
Activity < Limited Quantity limits
Less restrictive requirements applicable





LIMITED QUANTITY

MULTIPLE ISOTOPES – EXAMPLE (SOLID)

EXAMPLE: Am-241 0.009 TBq
Co-60 0.0004 TBq
Cs-137 0.01 TBq
Special Form

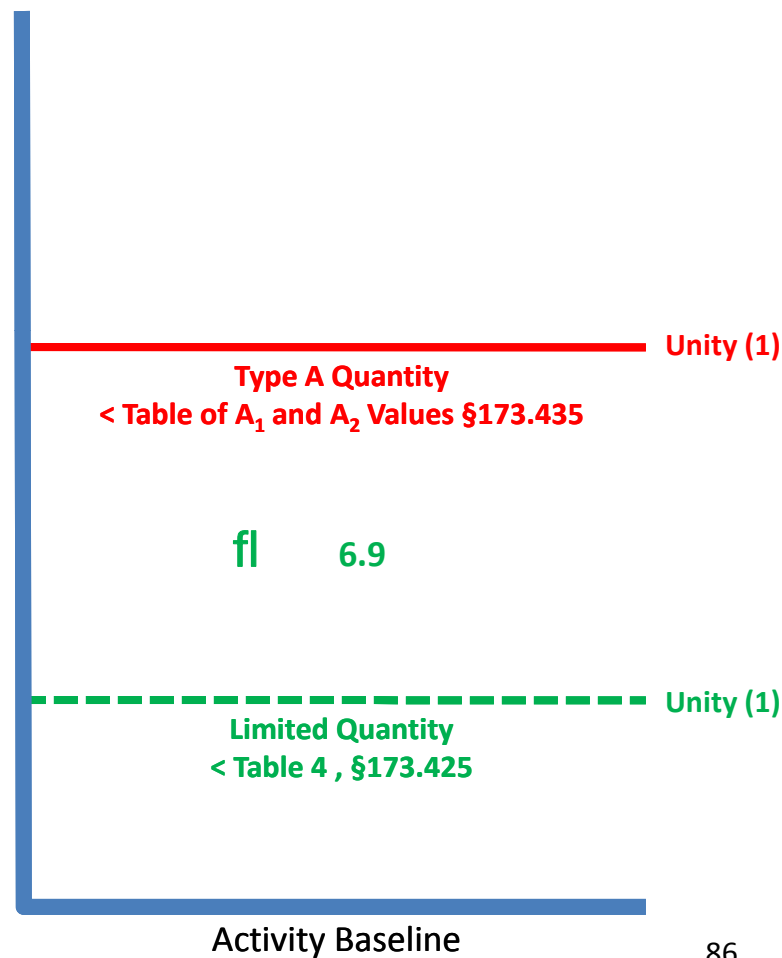
A₁ Values: Am-241 = 1 x 10¹ TBq (10 TBq)
Co-60 = 4 x 10⁻¹ TBq (0.4 TBq)
Cs-137 = 2.0 TBq

$$\text{Am-241} = \frac{0.009 \text{ TBq}}{10 \times 10^{-3} \text{ TBq}} = 0.9$$

$$\text{Co-60} = \frac{0.0004 \text{ TBq}}{0.4 \times 10^{-3} \text{ TBq}} = 1.0$$

$$\text{Cs-137} = \frac{0.01 \text{ TBq}}{2 \times 10^{-3} \text{ TBq}} = 5.0$$

TOTAL: = 6.9





TYPE B/HRCQ ACTIVITY LIMITS

- Type B: Quantity of material > Type A quantity (§173.403)
- HRCQ (§173.403) - a quantity within a single package which exceeds:
 - 3,000 times the A_1 value specified in §173.435 for special form;
 - 3,000 times the A_2 value specified in §173.435 for normal form; or
 - 1,000 TBq (27,000 Ci) whichever is least



LIMITED QUANTITY

SINGLE ISOTOPE – EXAMPLE (SOLID)

EXAMPLE: Co-60
Special Form
1,200 TBq

A_1 Value = 4×10^{-1} TBq (0.4 TBq)
Activity > Type A quantity limits
More restrictive requirements applicable

Activity > HRCQ limit (1,000 TBq)

