Table 2-12. Basic radionuclides values for individual radionuclides

Column 1	Column 2	Column 3	Column 4	Column 5
Radionuclide (atomic number)	*A_1 (TBq)*	*A_2 (TBq)*	*Activity concentration for exempt material (Bq/g)*	*Activity limit for an exempt consignment (Bq)*
Cobalt (27)				
Co-60	4×10^{-1}	4×10^{-1}	1×10^{1}	1×10^{5}
Molybdenum (42)				
Mo-93	4×10^{1}	2×10^{1}	1×10^{3}	1×10^{8}
	A_1.** The activity value of **special form radioactive material**, which is listed in Table 2-15 or derived in 7.2.2.2 and is used to determine the activity limits for the requirements of these Instructions.* ***Special form radioactive material**. Either:* *a) an indispersible solid radioactive material; or* *b) a sealed capsule containing radioactive material. (2;7.1.3)* ***Specific activity of a radionuclide**. The activity per unit mass of that nuclide. (2;7.1.3)* ***Specific activity of a material *The specific activity of a material means the activity per unit mass of the material in which the radionuclides are essentially uniformly distributed. (2;7.1.3)* 	***A_2.** The activity value of radioactive material, **other than special form radioactive material**, which is listed in Table 2-15 or derived in 7.2.2.2 and is used to determine the activity limits for the requirements of these Instructions.* 	*	*

* In order for a shipper to determine if a material must be classified as radioactive material the shipper must know the activity concentration of the material (specific activity of the material) as well as the total activity of his consignment. The Instructions stipulate that only when the activity concentration (the value found in column 4 of Table 2-12) and the

activity limit of the consignment (the value found in column 5 of Table 2-12) have been exceeded must the material be considered as radioactive. (See also the definition for radioactive material.)

Example:

To determine if a shipment of Co-60, where an activity concentration of Co-60 is 5 Bq/g and an activity of the consignment is 150 kBq, is considered radioactive turn to columns 4 and 5 of Table 2-12 to find the "activity concentration for an exempt material" of Co-60 and the "activity limit for an exempt consignment".

The activity limit for an exempt material of Co-60 is 1 X 10^1 and the "activity limit for an exempt consignment" of Co-60 is 1 X 10^5. Although the activity for this consignment of Co-60 is higher than 100 kBq (i.e. 150 kBq), the activity concentration (5 Bq/g) is less than the activity concentration for an exempt material, i.e.10 Bq/g, therefore the material will not be classified as Class 7.

If the activity concentration was 20 Bq/g and the total activity was 150 kBq, then the material would be considered as Class 7.

Note.—

- *Specific activity of a radionuclide: the activity per unit mass of that nuclide. (2;7.1.3)*
- *Specific activity of a material: the activity per unit mass of the material in which the radionuclides are essentially uniformly distributed. (2;7.1.3)*

EXERCISE 9-3

Referring to Table 2-12, state whether the following shipments are subject to the Instructions.

	Shipment	Activity concentration	Total activity	
1.	I-125	100 Bq/g	2 MBq	
2.	Ir-192	20 Bq/g	2 MBq	
3.	C-14	Not defined	8.3 MBq	

Check your answers with those in Unit 13.

What if the radionuclide is not listed in Table 2-12?

Most well-known radionuclides are listed in Table 2-12, where the A1 and A2 values are well defined. Be aware these values are of the utmost importance as they give you the maximum allowed activity for a Type A package. (Further information on this will be provided at a later point in this unit.)

Where a radionuclide is not listed in Table 2-12, the determination of the radionuclide values requires "multilateral" approval, unless Table 2-13 is used. (2;7.2.2.2)

Table 2-13 records the basic radionuclide values for “unknown” radionuclides or mixtures.

2;7.2.2.3 In the calculations of A1 and A2 for a radionuclide not in Table 2-12, a single radioactive decay chain in which the radionuclides are present in their naturally occurring proportions, and in which no daughter nuclide has a half-life either longer than 10 days or longer than that of the parent nuclide, must be considered as a single radionuclide; and the activity to be taken into account and the A1 or A2 value to be applied must be that corresponding to the parent nuclide of that chain. In the case of radioactive decay chains in which any daughter nuclide has a half-life either longer than 10 days or greater than that of the parent nuclide, the parent and such daughter nuclides must be considered as mixtures of different nuclides.

Note.—

- *See 2;7.2.2.4 for instructions on how to calculate the basic radionuclide values for mixtures of radionuclides.*
- *See 2;7.2.2.5 for instructions on how to determine the radionuclide value when the identity of each radionuclide is known, but the individual activities of some of the radionuclides are not known.*

EXERCISE 9-4

Referring to Table 2-12 or 2-13, state the A1 and A2 values in GBq for the following radionuclides.

1. Lu-177		
2. F-18		
3. Bi-205		
4. Cf-252		
5. Unknown gamma emitting nuclide		

Check your answers with those in Unit 13.

Radioactive material has been assigned 25 UN numbers. These UN numbers and their respective proper shipping name(s) are divided into nine groups and are found in Table 2-11 of the Instructions.

The classification of each of the nine groups is as follows.

1.	Excepted packages (1;6.1.5 and 2;7.2.4)

This first group “Excepted packages” is different from the other eight groups.

2;7.2.4.1.1. Packages may be classified as excepted packages if:

a) they are empty packagings having contained radioactive material;

b) they contain instruments or articles in limited quantities;

c) they contain articles manufactured of natural uranium, depleted uranium or natural thorium; or

d) they contain radioactive material in limited quantities.

2;7.2.4.1.1.2 A package containing radioactive material may be classified as an excepted package provided that the radiation level at any point on its external surface does not exceed 5 μSv/h.

There are seven proper shipping names assigned to the four UN numbers of this group. The following table matches the proper shipping name with their respective requirements.

Note.— Always refer to the Instructions for the complete text of a requirement.

UN number	*Proper shipping name and reference number*	*Summary of criteria*
UN 2908	**Radioactive material, excepted package — empty packaging** (2;7.2.4.1.1.5)	— Applies to an empty packaging which had previously contained radioactive material with an activity not exceeding the limit specified in column 4 of Table 2-15*. — The package is well-maintained and securely closed. — The outer surface of any uranium or thorium is covered with an inactive sheath. — The level of internal non-fixed contamination is specifically limited. — Any radioactive material labels are no longer visible.
UN 2911	**Radioactive material, excepted package — instruments** or **Radioactive material, excepted package — articles** (2;7.2.4.1.1.3)	— Applies to radioactive material which is enclosed in or is included as a component part of an instrument or other manufactured article. — Radiation level outside the package is specifically limited. — The instrument or article must be marked “RADIOACTIVE”, unless otherwise specified. — The active material is completely enclosed. — The limits specified in Columns 2 and 3 of Table 2-15* are met for each item and each package.
UN 2909	**Radioactive material, excepted package — articles manufactured from natural uranium** or **Radioactive material, excepted package — depleted uranium** or **Radioactive material, excepted package — natural thorium** (2;7.2.4.1.2)	— Applies to articles manufactured of natural uranium, depleted uranium or natural thorium and articles in which the sole radioactive material is unirradiated natural uranium, unirradiated depleted uranium or unirradiated natural thorium. — Outer surface of the uranium or thorium is enclosed in an inactive sheath.
UN 2910	**Radioactive material, excepted package — limited quantity of material** (2;7.2.4.1.1.4)	— Applies to radioactive material with an activity not exceeding the limit specified in Column 4 of Table 2-15*. — The package must be able to retain its radioactive contents during transport. — The package displays the mark “RADIOACTIVE” on an internal surface to warn anyone who opens it that radioactive material is present.

* Three of the four UN numbers refer to limits established in Table 2-15 of the Instructions. This table establishes the activity limits for the physical state of an “Excepted Package” (i.e. solid, liquid or gas) by “Instrument or article” and by “Materials”.

Example:

Question: Ni-63, metal alloy, other form, 0.01 TBq. Can this material be shipped as an excepted package of radioactive material?

Instructions:

- Ni-63, metal alloy, other form is a solid, other form radioactive material *(Note.— It is not an instrument or article)*.

- Locate in the left-hand column of Table 2-15 under the heading *Physical state of contents* the entry for

  Solids
  Other form

- Adjacent to this entry in the right-hand column of Table 2-15, under the heading *Materials — Package limits* is the limit '10^{-3} A_2'.

- Referring to Table 2-12, locate the A_2 value for Ni-63. The value is 30 TBq.
  Note that 10^{-3} x 30 TBq = **0.03 TBq**.

Answer:

- 0.03 TBq is the maximum allowed activity for an excepted package of Ni-63, solid in other form which means that we can transport the above-mentioned material as an excepted package of radioactive material (0.01 TBq <0.03 TBq).

  Note.— This package may only be classified as an excepted package provided that the radiation level at any point on its external surface does not exceed 5 µSv/h.

- The correct UN number to be used for this material is UN 2910, the proper shipping name is **Radioactive material, excepted package — limited quantity of material**.

Note.— Due to the reduced risk posed by radioactive material, excepted packages, certain exceptions from Part 5 — Shipper's Responsibilities and Part 7 — Operator's Responsibilities of the Instructions apply. (More information on the applicable requirements is provided below in this unit.)

The remaining eight groups are as follows:

2.	Low specific activity radioactive material (2;7.2.3.1)
3.	Surface contaminated objects (2;7.2.3.2)
4.	Type A packages (2;7.2.4.4)
5	Type B(U) package (2;7.2.4.6)
6.	Type B(M) package (2;7.2.4.6)

7.	Type C package (2;7.2.4.6)

8.	Uranium hexafluoride (2;7.2.4.5)

9.	Special arrangement (2;7.2.5)

Note.— Radioactive materials assigned to these eight groups are not entitled to any exceptions and must comply with all applicable provisions of the Instructions.

Interpretation tools

To begin the classification process for assigning proper shipping names and UN numbers to these eight groups, two essential tools are needed:

1. definitions for words used in the proper shipping name; and
2. the basic radionuclides values established in:
   - Table 2-12 for each radionuclide, or
   - Table 2-13 for mixtures of radionuclides for which relevant data are not available.

Definitions

Each proper shipping name contains a combination of words that distinguishes it from the other proper shipping names that apply to radioactive material. These words have specific meanings. For example, the proper shipping name “Uranium hexafluoride, fissile” is made up of the words:

- “Uranium hexafluoride” which is a binary compound of uranium and fluorine, UF_6; it is a grey solid, or heavy gas, and is used in the uranium enrichment process to produce fuel for nuclear reactors or nuclear weapons. (Wikipedia)

and

- “Fissile” which includes uranium-233, uranium-235, plutonium-239, plutonium-241, or any combination of these radionuclides. (2;7.1.3)

Pertinent words found in the proper shipping names have been listed below, and a detailed description of each can be found by looking up the adjacent reference number:

Word(s)	*Explanation*
Fissile	2;7.1.3 and 2;7.2.3.5 and 6;7.10
Fissile Excepted	2;7.2.3.5 and 6;7.10.2
Special Form radioactive material	2;7.1.3 and 2; 7.2.3.3
Special form fissile	2;7.1.3, 2;7.2.3.5 and 2;7.2.3.3
Low disperable radioactive material	1;3 and 2; 7.2.3.4
Low specific activity	2;7.1.3
Surface Contaminated Object	2;7.1.3

Word(s)	*Explanation*
Type A package	6;7.6
Type B(U) package	6;7.7
Type B(M) package	6;7.8
Type C package	6;7.9
Special arrangement	1;6.4
Uranium hexafluoride package	6;7.5
Natural, depleted or enriched uranium	2;7.1.3

Using the definitions and the tables in Part 2;7 of the Instructions we are now ready to examine the classification requirements of the remaining eight groups, starting with low specific activity radioactive material.

2.	Low specific activity radioactive material (2;7.2.3.1)

Radioactive material may only be classified as “Low specific activity radioactive material” if the conditions of 2;7.2.3.1 and 4;9.1 of the Instructions apply.

There are five proper shipping names assigned to this group:

Low specific activity radioactive material (7.2.3.1)

UN number	*Proper shipping name*
UN 2912	**Radioactive material, low specific activity (LSA-I)**, non-fissile or fissile excepted (2;7.2.3.1.2 a)).
UN 3321	**Radioactive material, low specific activity (LSA-II)**, non-fissile or fissile excepted (2;7.2.3.1.2 b)).
UN 3322	**Radioactive material, low specific activity (LSA-III)**, non-fissile or fissile excepted (2;7.2.3.1.2 c), 2;7.2.3.1.3, 2;7.2.3.1.4 and 2;7.2.3.1.5.
UN 3324	**Radioactive material, low specific activity (LSA-II) fissile**.
UN 3325	**Radioactive material, low specific activity (LSA-III) fissile**.

2; 7.2.4.2.1 Radioactive material may only be classified as LSA material if the conditions of 7.2.3.1 and 4;9.2.1 are met.

Each proper shipping name of this group has two sections:

a) The first section indicates whether it is an LSA I, II or III.

b) The second section indicates whether it applies to a non-fissile, fissile excepted or fissile radioactive material.

The criteria for assigning LSA I, II or III are as follows:

- **LSA – I**
  Sub-paragraph 2;7.2.3.1.2 a) lists and describes the radioactive material that has been assigned this proper shipping name.

- **LSA – II**
  Sub-paragraph 2;7.2.3.1.2 b) lists and describes the radioactive material that has been assigned this proper shipping name.

- **LSA – III**
  Sub-paragraphs 2;7.2.3.1.2 c) and 2;7.2.3.1.3 list and describe the radioactive material that has been assigned this proper shipping name.
  Sub-paragraphs 2;7.2.3.1.4 and 2;7.2.3.1.5 state the LSA III material testing requirements.

For determining if it is "fissile excepted" or "fissile" radioactive material, see the definitions provided in the tools above.

3.	Surface contaminated objects (2;7.2.3.2)

Radioactive material may only be classified as "Surface contaminated objects" if the conditions of 2;7.2.3.2 of the Instructions apply.

There are four proper shipping names assigned to this group.

Surface contaminated objects (7.2.3.2)

UN number	*Proper shipping name*
UN 2913	**Radioactive material, surface contaminated objects (SCO-I** or **SCO-II)**, non-fissile or fissile excepted.
UN 3326	**Radioactive material, surface contaminated objects (SCO-I** or **SCO-II), fissile**.

As with LSA material, each proper shipping name of this group has two sections:

a) The first section indicates whether it is SCO I or II.

b) The second section indicates whether it applies to a non-fissile, fissile excepted or fissile radioactive material.

The criteria for assigning SCO I or II are indicated below:

- **SCO I** (2;7.2.3.2.1 a))
  Applies to a solid object with specific limits in place for:
  - the non-fixed contamination on the accessible surface
  - the fixed contamination on the accessible surface.
  - the non-fixed contamination plus the fixed contamination on the inaccessible surface.

- **SCO II** (2;7.2.3.2.1 b))
  Applies to a solid object on which either the fixed or non-fixed contamination on the surface exceeds the applicable limits specified for SCO – I, but is limited for:
  - the non-fixed contamination on the accessible surface
  - the fixed contamination on the accessible surface
  - the non-fixed contamination plus the fixed contamination on the inaccessible surface.

For determining if it is "fissile excepted" or "fissile" radioactive material, see the definitions provided in the tools above.

Note.— The shipper must make available for inspection by the relevant competent authority documentary evidence of the compliance of the package design with all the applicable requirements.

4.	Type A packages (2;7.2.4.4)

Radioactive material may only be classified as a Type A package if the conditions of 2;7.2.4.4 of the Instructions apply.

2;7.2.4.4.1.1 Type A packages must not contain activities greater than the following:

a) for special form radioactive material — A1; or

b) for all other radioactive material — A2.

There are four proper shipping names assigned to this group.

Type A packages (7.2.4.4)

UN number	*Proper shipping name*
UN 2915	**Radioactive material, Type A package**, non-special form, non-fissile or fissile excepted.
UN 3327	**Radioactive material, Type A package, fissile**, non-special form.
UN 3332	**Radioactive material, Type A package, special form**, non-fissile or fissile excepted.
UN 3333	**Radioactive material, Type A package, special form, fissile.**

Note.— To locate the definitions for the words non-special form, fissile excepted, fissile non-special form, special form fissile excepted and special form fissile see the references provided at the beginning of Step 4.

Sub-paragraph 2;7.2.4.4 establishes the criteria for the Type A package:

- a maximum activity level; and
- where mixtures or radionuclides whose identities and respective activities are known, certain conditions are specified. (2; 7.2.4.4.1.2.)

Note.— The shipper must make available for inspection by the relevant competent authority documentary evidence of the compliance of the package design with all the applicable requirements.

5.	Type B(U) package (2;7.2.4.6)

Radioactive material may only be classified as a Type B(U) package if the conditions of 2;7.2.4.6 of the Instructions apply.

Two proper shipping names and their corresponding UN numbers are in this group.

Type B(U) package (7.2.4.6)

UN number	*Proper shipping name*
UN 2916	**Radioactive material, Type B(U) package**, non-fissile or fissile excepted.
UN 3328	**Radioactive material, Type B(U) package, fissile**.

Sub-paragraph 2;7.2.4.6.2 establishes what the Type B(U) must **not** contain. *(See Part 6;7 for information on what it may contain.)*

Note.— To locate the definitions for the words fissile excepted and fissile see the references provided at the beginning of Step 4.

6.	Type B(M) package (2;7.2.4.6)

Radioactive material may only be classified as a Type B(U) package if the conditions of 2;7.2.4.6 of the Instructions apply.

Note.— A Type B(M) package is a package which does not comply with all requirements for a Type B(U) package. For that reason multilateral approval is required and the transport is only allowed on CAO.

Two proper shipping names and their corresponding UN numbers appear for Type B(M) packages.

Type B(M) package (7.2.4.6)

UN number	*Proper shipping name*
UN 2917	**Radioactive material, Type B(M) package**, non-fissile or fissile excepted.
UN 3329	**Radioactive material, Type B(M) package, fissile**.

Sub-paragraph 2;7.2.4.6.3 establishes what the Type B(M) must **not** contain. *(See Part 6;7 for information on what it may contain.)*

Note.— To locate the definitions for the words fissile excepted and fissile see the references provided at the beginning of Step 4.

7.	Type C package (7.2.4.6)

Radioactive material may only be classified as a Type C package if the conditions of 2;7.2.4.6 of the Instructions apply.

Two proper shipping names and their corresponding UN numbers appear for Type C packages.

Sub-paragraph 2; 7.2.4.6.4 establishes what the Type C must **not** contain. *(See Part 6;7 for information on what it may contain.)*

Type C package (7.2.4.6)

UN number	*Proper shipping name*
UN 3323	**Radioactive material, Type C package**, non-fissile or fissile excepted.
UN 3330	**Radioactive material, Type C package, fissile**.

Note.— Currently Type C packages are not on the market.

Note.— To locate the definitions for the words fissile excepted and fissile see the references provided at the beginning of Step 4.