EASA
European Union Aviation Safety Agency

Safe Transport of Dangerous Goods by Air

Joseph LE-TONQUEZE – Pascal TATIN

DG Experts (EASA EU-South East Asia Aviation Partnership Project Experts)

20-23 January 2020

Your safety is our mission.

An Agency of the European Union

EU-South East Asia Aviation Partnership Project (EU-SEA APP)
This project is funded by the European Union and implemented by the European Union Aviation Safety Agency - EASA

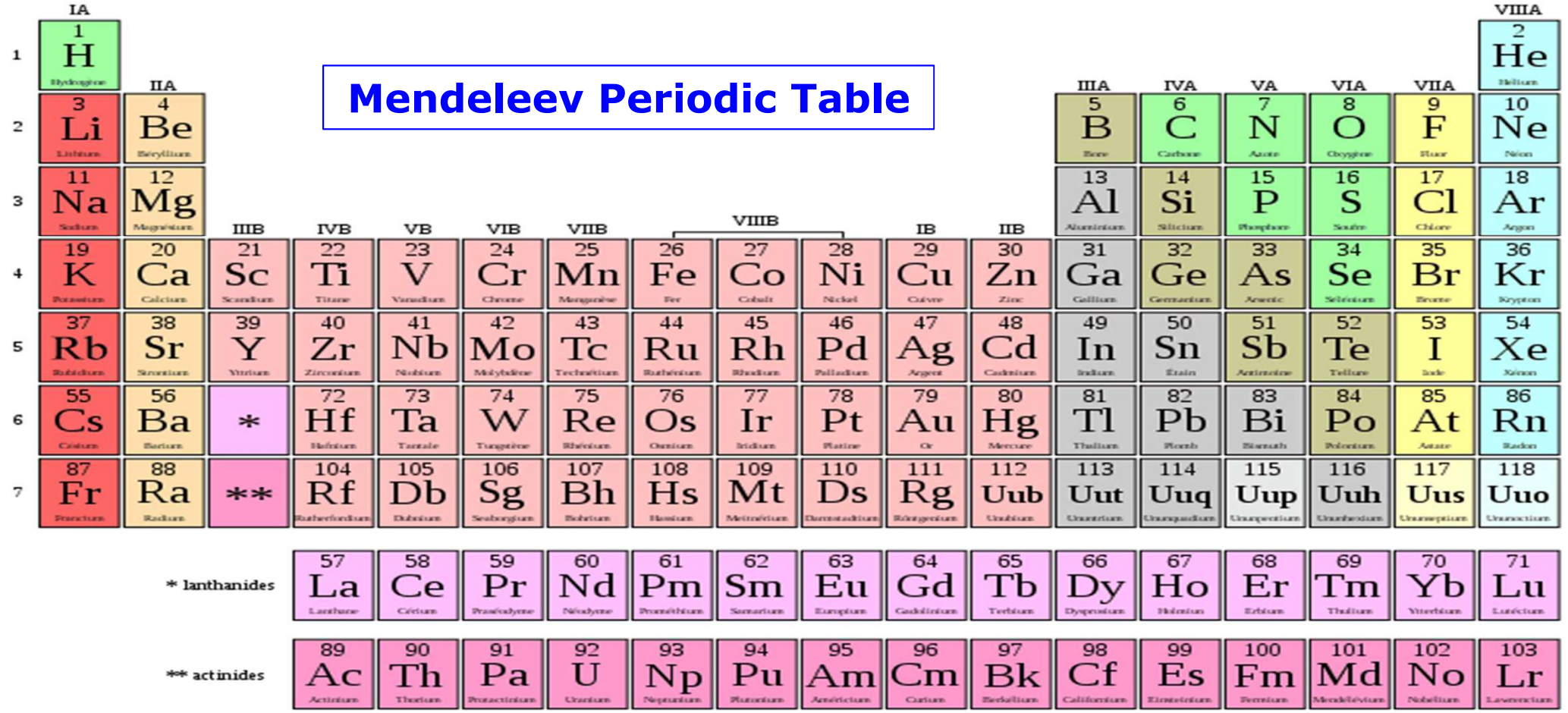
EASA
European Union Aviation Safety Agency

Safe Transport of Dangerous Goods by Air

Part 10 – Radioactive Material

ATOMS

- **Material** is an **atom combination**
- There is around **100 kind of different atoms**
- The **difference** between atoms is **related** to their **internal structure**, and to their **chemical properties**



ATOM'S ISOTOPES

- A kind of atom exists in several "sort", named isotopes

- 2 isotopes of an atom have:

✓ the same chemical properties

✓ different masses

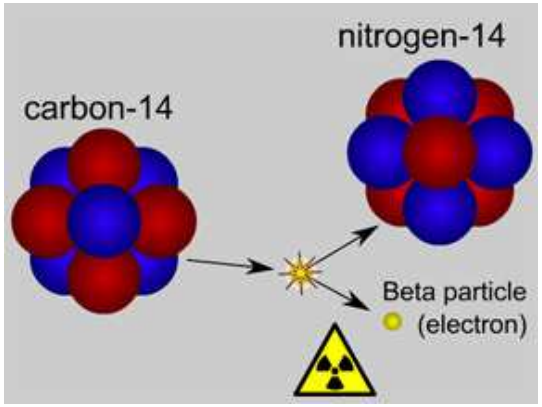
→ Example: Standard Carbon = "Carbon 12", but there is also "Carbon 14"

- Some isotopes are unstable, and named "radioisotope"

→ Example: Carbon 14 isotopes are disintegrating themselves in a natural way

- A disintegration is a transformation in another isotope/atom and particle emission or a radiation

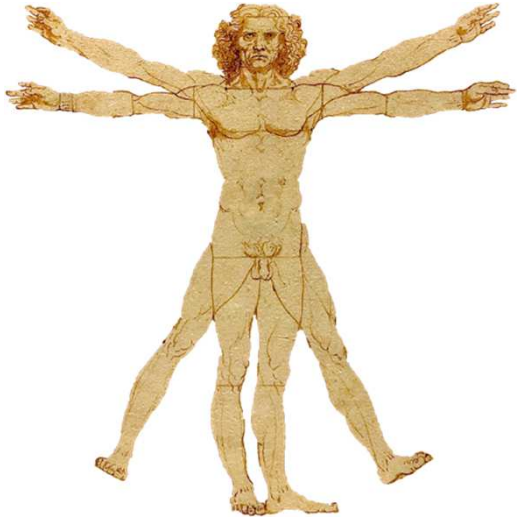
→ Example: Carbon 14 = Nitrogen 14 + << β^- >>



BECQUEREL

- **Definition: 1 disintegration per minute = 1 Becquerel (Bq)**

- **Usual activities:**



✓ **1 banana = 20 Bq**

✓ **human body = 100 Bq / kg**

✓ **into a radiopharmaceutical package "RRY" carried by air = 50 to 100 GBq**

(1 GBQ = 1 000 000 000 Bq = 10^9 Bq)

SIEVERT

➢ **When there is a disintegration (transformation in another isotope and particle emission or radiation):**

→ **different types of radiation/particle may occur (α, β^+, β^-, γ, neutron)**

→ **the radiation type and the associated energy are dependent to the radionuclide**

➢ **Definition:**

→ **Sievert is the measurement of the damages done by the radiation on human body**

➢ **As the type of radiation and its associated energy is dependent to each radionuclide**

➔ **there is no direct link between Becquerel and Sievert**

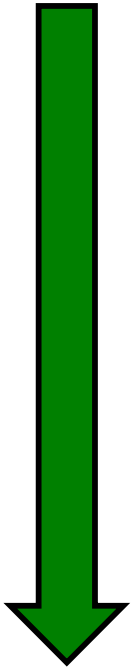
SIEVERT

- **radiation exposure time (examples):**

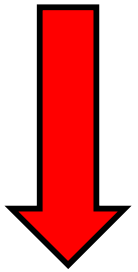
- ✓ **to eat a banana: 0,1 µSv**
- ✓ **teeth panoramic radio: 5 µSv**
- ✓ **exposure limit for public (except medical, …): 1 mSv/year**
- ✓ **average natural radioactivity in Europe:**

2,4 mSv/year/habitant (can be 10 to 50 mSv in certain parts of India, China or Brazil)

- ✓ **crew staff: 3 to 5 mSv/year**
- ✓ **thoracic scanner: 7 mSv**
- ✓ **exposure limit for nuclear workers: 20 mSv/year**



- **100 mSv exposure once = 15 % increasing of cancer's risk**
- **1 Sv exposure once = burns**
- **5 Sv exposure once = 50 % chance to survive**



Protection against radiation

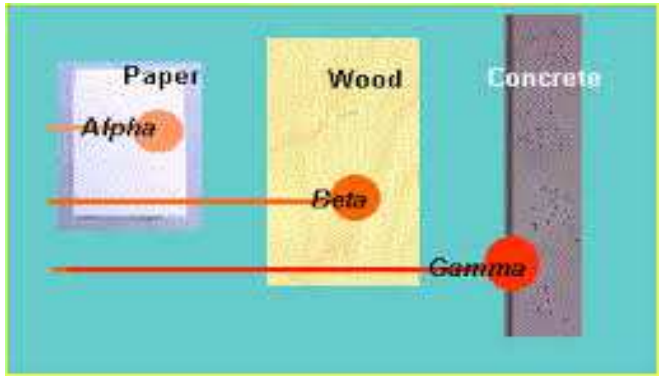
- **3 types of protection:**

✓ **Time: reduction of the time spent near a radiation source**

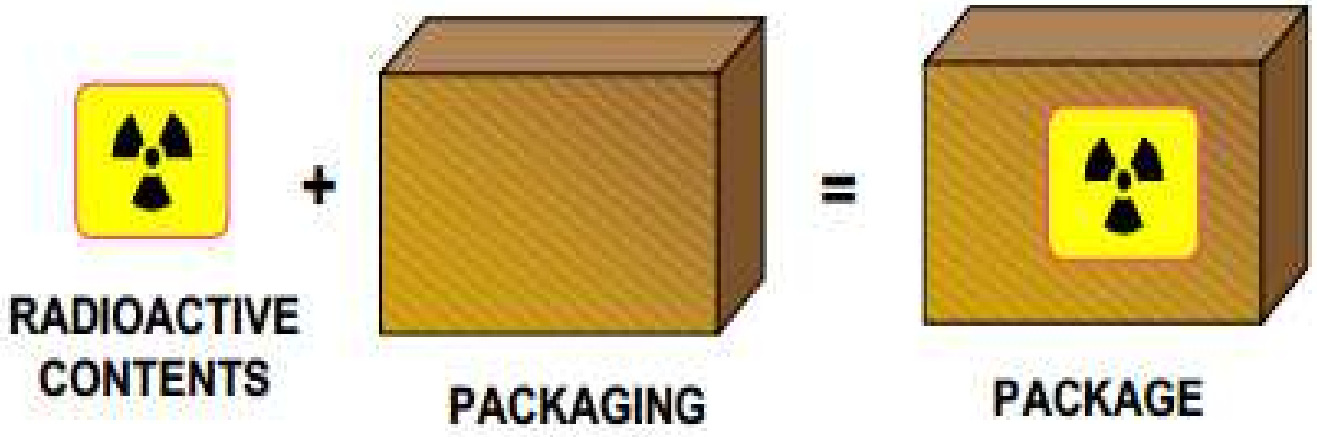
✓ **Distance: exposure decreases with square distance**

- **at 1 m → 4 mSv/h**
- **at 2 m → 1 mSv/h**
- **at 10 m → 0,04 mSv/h**

✓ **Screen: radiation is absorbed by these material**

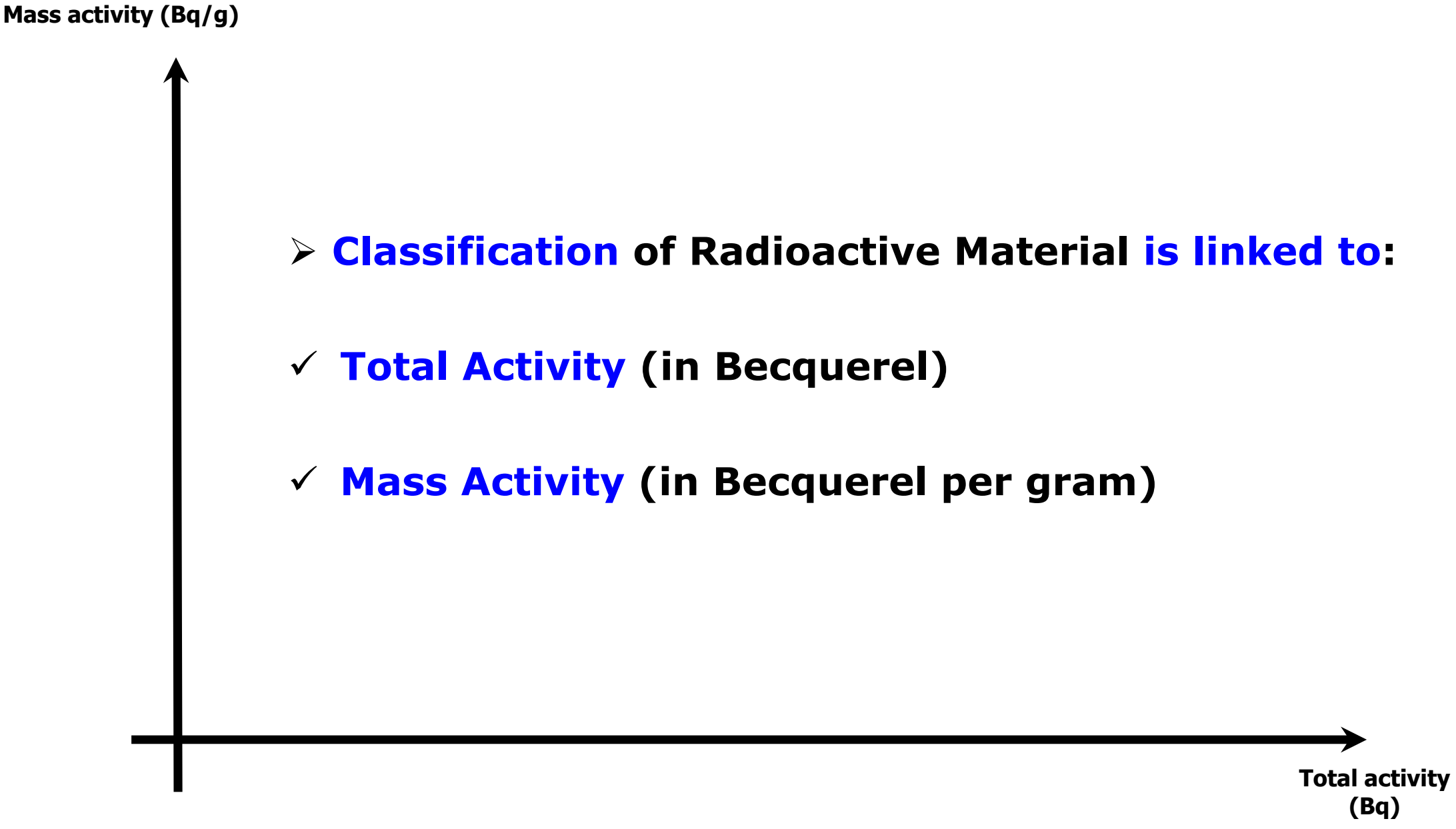


Terminology



- **Safety is first put back on the package**

- **More dangerous is the contents, more resistant the package shall be !**
- **There is different types of packages, for different types and quantity of material, depending of their dangerousness**



- **Classification of Radioactive Material is linked to:**
  - ✓ **Total Activity (in Becquerel)**
  - ✓ **Mass Activity (in Becquerel per gram)**

Exempted Material

- **Conditions to be fully exempted:**

→ **for each radionuclide, depending of its atomic number**

Activity Concentration Limit

OR

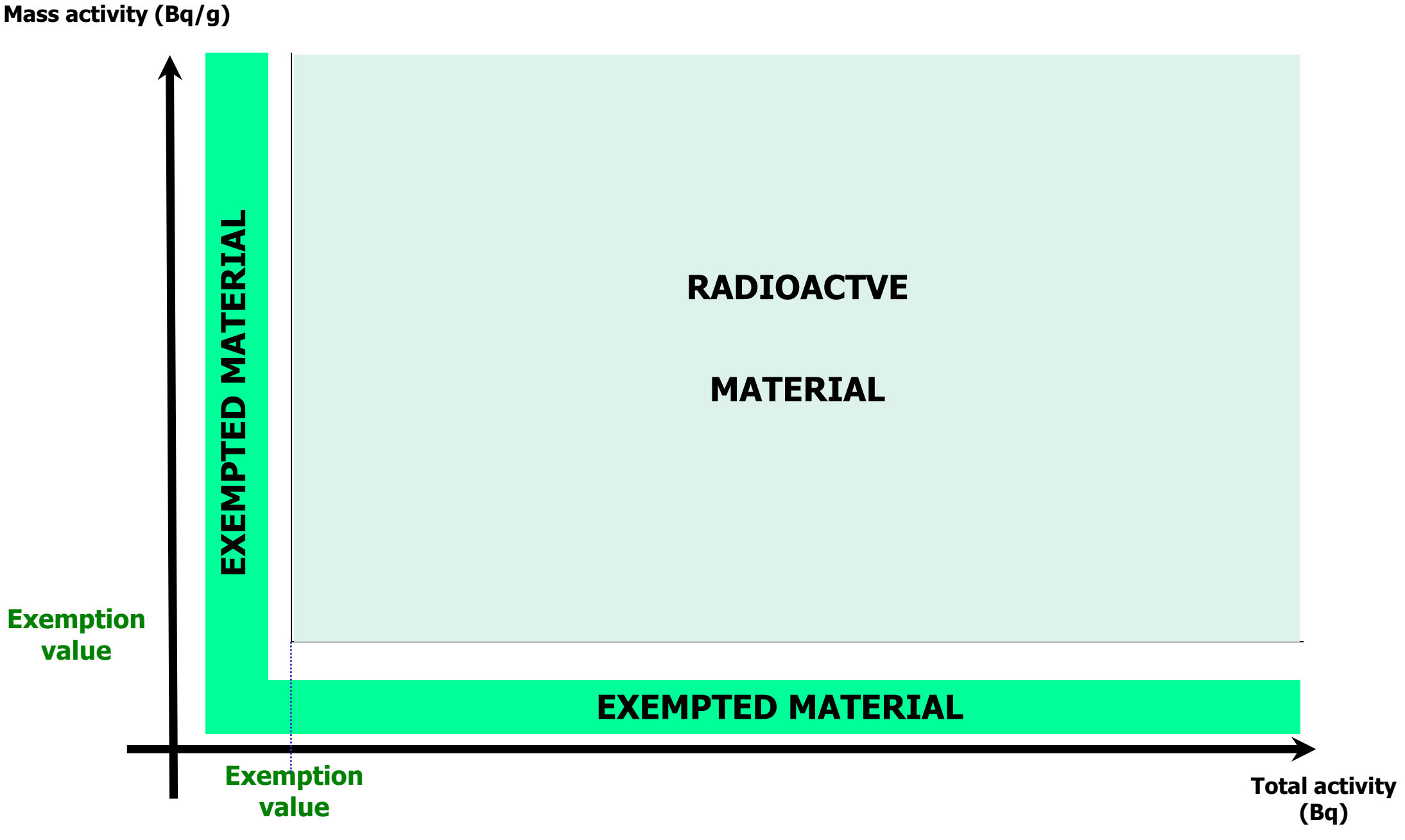
Activity Limit per package

<

Threshold Limit (Table 2-12)

Table 2-12. Basic radionuclides values for individual radionuclides

Radionuclide (atomic number)	*Special form A_1 (TBq)*	*Other form A_2 (TBq)*	*Activity concentration limit for exempt material (Bq/g)*	*Activity limit for an exempt consignment (Bq)*
Actinium (89)				
Ac-225 (a)	8×10^{-1}	6×10^{-3}	1×10^{1}	1×10^{4}
Ac-227 (a)	9×10^{-1}	9×10^{-5}	1×10^{-1}	1×10^{3}
Ac-228	6×10^{-1}	5×10^{-1}	1×10^{1}	1×10^{6}
Silver (47)				
Ag-105	2×10^{0}	2×10^{0}	1×10^{2}	1×10^{6}
Ag-108m (a)	7×10^{-1}	7×10^{-1}	1×10^{1} (b)	1×10^{6} (b)
Ag-110m (a)	4×10^{-1}	4×10^{-1}	1×10^{1}	1×10^{6}
Ag-111	2×10^{0}	6×10^{-1}	1×10^{3}	1×10^{6}


Mass activity (Bq/g)
EXEMPTED MATERIAL
RADIOACTVE
MATERIAL
Exemption value
EXEMPTED MATERIAL
Exemption value
Total activity (Bq)

Radioactive Material

- **A radioactive material can be classified as:**
  - → **Excepted package**
  - → **Type A Package**
  - → **Type B Package**
  - → **Industrial Package (IP1, IP2, IP3)**
  - → **Type C Package**

- **For each radionuclide, it has been determined a risk threshold as:**

30 mn of exposure at 1 m of the material without protection = 50 mSv

- **it gives two values:**
  - → **A_1 = activity of the radionuclide which is in a form non "easily dispersible", called "special form"**
  - → **A_2 = activity of the radionuclide which is in a "dispersible" form, called "non-special form"**
  - → **Table 2-12** (IATA DGR Table 10.3.A) **provides these basic radionuclides values for individual radionuclides**

Table 2-12. Basic radionuclides values for individual radionuclides

Radionuclide (atomic number)	*Special form A_1 (TBq)*	*Other form A_2 (TBq)*	*Activity concentration limit for exempt material (Bq/g)*	*Activity limit for an exempt consignment (Bq)*
Actinium (89)				
Ac-225 (a)	8×10^{-1}	6×10^{-3}	1×10^{1}	1×10^{4}
Ac-227 (a)	9×10^{-1}	9×10^{-5}	1×10^{-1}	1×10^{3}
Ac-228	6×10^{-1}	5×10^{-1}	1×10^{1}	1×10^{6}
Silver (47)				
Ag-105	2×10^{0}	2×10^{0}	1×10^{2}	1×10^{6}
Ag-108m (a)	7×10^{-1}	7×10^{-1}	1×10^{1} (b)	1×10^{6} (b)
Ag-110m (a)	4×10^{-1}	4×10^{-1}	1×10^{1}	1×10^{6}
Ag-111	2×10^{0}	6×10^{-1}	1×10^{3}	1×10^{6}
Aluminium (13)				
Al-26	1×10^{-1}	1×10^{-1}	1×10^{1}	1×10^{5}
Americium (95)				
Am-241	1×10^{1}	1×10^{-3}	1×10^{0}	1×10^{4}
Am-242m (a)	1×10^{1}	1×10^{-3}	1×10^{0} (b)	1×10^{4} (b)
Am-243 (a)	5×10^{0}	1×10^{-3}	1×10^{0} (b)	1×10^{3} (b)
Argon (18)				
Ar-37	4×10^{1}	4×10^{1}	1×10^{6}	1×10^{8}
Ar-39	4×10^{1}	2×10^{1}	1×10^{7}	1×10^{4}
Ar-41	3×10^{-1}	3×10^{-1}	1×10^{2}	1×10^{9}
Arsenic (33)				
As-72	3×10^{-1}	3×10^{-1}	1×10^{1}	1×10^{5}
As-73	4×10^{1}	4×10^{1}	1×10^{3}	1×10^{7}
As-74	1×10^{0}	9×10^{-1}	1×10^{1}	1×10^{6}
As-76	3×10^{-1}	3×10^{-1}	1×10^{2}	1×10^{5}
As-77	2×10^{1}	7×10^{-1}	1×10^{3}	1×10^{6}
Astatine (85)				
At-211 (a)	2×10^{1}	5×10^{-1}	1×10^{3}	1×10^{7}
Gold (79)				
Au-193	7×10^{0}	2×10^{0}	1×10^{2}	1×10^{7}
Au-194	1×10^{0}	1×10^{0}	1×10^{1}	1×10^{6}
Au-195	1×10^{1}	6×10^{0}	1×10^{2}	1×10^{7}
Au-198	1×10^{0}	6×10^{-1}	1×10^{2}	1×10^{6}
Au-199	1×10^{1}	6×10^{-1}	1×10^{2}	1×10^{5}
Barium (56)				
Ba-131 (a)	2×10^{0}	2×10^{0}	1×10^{2}	1×10^{6}
Ba-133	3×10^{0}	3×10^{0}	1×10^{2}	1×10^{5}
Ba-133m	2×10^{1}	6×10^{-1}	1×10^{2}	1×10^{6}
Ba-140 (a)	5×10^{-1}	3×10^{-1}	1×10^{1} (b)	1×10^{5} (b)
Beryllium (4)				
Be-7	2×10^{1}	2×10^{1}	1×10^{3}	1×10^{7}
Be-10	4×10^{1}	6×10^{-1}	1×10^{4}	1×10^{6}
Bismuth (83)				
Bi-205	7×10^{-1}	7×10^{-1}	1×10^{1}	1×10^{6}
Bi-206	3×10^{-1}	3×10^{-1}	1×10^{1}	1×10^{5}
Bi-207	7×10^{-1}	7×10^{-1}	1×10^{1}	1×10^{6}
Bi-210	1×10^{0}	6×10^{-1}	1×10^{3}	1×10^{6}
Bi-210m(a)	6×10^{-1}	2×10^{-2}	1×10^{1}	1×10^{5}
Bi-212 (a)	7×10^{-1}	6×10^{-1}	1×10^{1} (b)	1×10^{5} (b)
Berkelium (97)				
Bk-247	8×10^{0}	8×10^{-4}	1×10^{0}	1×10^{4}
Bk-249 (a)	4×10^{1}	3×10^{-1}	1×10^{3}	1×10^{6}
Bromine (35)				
Br-76	4×10^{-1}	4×10^{-1}	1×10^{1}	1×10^{5}
Br-77	3×10^{0}	3×10^{0}	1×10^{2}	1×10^{6}
Br-82	4×10^{-1}	4×10^{-1}	1×10^{1}	1×10^{6}
Carbon (6)				
C-11	1×10^{0}	6×10^{-1}	1×10^{1}	1×10^{6}
C-14	4×10^{1}	3×10^{0}	1×10^{4}	1×10^{7}
Calcium (20)				
Ca-41	Unlimited	Unlimited	1×10^{5}	1×10^{7}
Ca-45	4×10^{1}	1×10^{0}	1×10^{4}	1×10^{7}
Ca-47 (a)	3×10^{0}	3×10^{-1}	1×10^{1}	1×10^{6}
Cadmium (48)				
Cd-109	3×10^{1}	2×10^{0}	1×10^{4}	1×10^{6}
Cd-113m	4×10^{1}	5×10^{-1}	1×10^{3}	1×10^{5}
Cd-115 (a)	3×10^{0}	4×10^{-1}	1×10^{2}	1×10^{6}
Cd-115m	5×10^{-1}	5×10^{-1}	1×10^{3}	1×10^{6}
Cerium (58)				
Ce-139	7×10^{0}	2×10^{0}	1×10^{2}	1×10^{6}
Ce-141	2×10^{1}	6×10^{-1}	1×10^{2}	1×10^{7}
Ce-143	9×10^{-1}	6×10^{-1}	1×10^{2}	1×10^{6}
Ce-144 (a)	2×10^{-1}	2×10^{-1}	1×10^{2} (b)	1×10^{5} (b)
Californium (98)				

Excepted Package

- **Shall respect the limit activity indicated in Table 2-14** (Table 10.3.C), **depending of the physical state of content (solid, liquid, gas), and if it is an instrument/article or a material**

Table 2-14. Activity limits for excepted packages

	Instruments or article		*Materials*
Physical state of contents	*Item limits**	*Package limits**	*Package limits**
Solids			
Special form	10^{-2} A_1	A_1	10^{-3} A_1
Other form	10^{-2} A_2	A_2	10^{-3} A_2
Liquids	10^{-3} A_2	10^{-1} A_2	10^{-4} A_2
Gases			
Tritium	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
Other forms	10^{-3} A_2	10^{-2} A_2	10^{-3} A_2

Excepted Package

- **Examples:**

toxic gas detector

lead analyzer and its bag

immune diagnosis

Excepted Package

- Example of the lead analyser and its bag = Package

→ Limit to be classified as an excepted package is A_1 in Bq

- Example of toxic gas detector:

✓ each detector = article, but whole in a packaging = package

Table 2-14. Activity limits for excepted packages

	Instruments or article		*Materials*
Physical state of contents	*Item limits**	*Package limits**	*Package limits**
Solids			
Special form	10^{-2} A_1	A_1	10^{-3} A_1
Other form	10^{-2} A_2	A_2	10^{-3} A_2
Liquids	10^{-3} A_2	10^{-1} A_2	10^{-4} A_2
Gases			
Tritium	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
Other forms	10^{-3} A_2	10^{-2} A_2	10^{-3} A_2

Additional limit: 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

Mass activity (Bq/g)

EXCEPTED PACKAGE

EXEMPTED MATERIAL

EXEMPTED MATERIAL

Exemption value

Exemption value

10^{-n} A_1 or A_2

Total activity (Bq)

Type A Packages

- **Examples:**

gamma density meter

Radiopharmaceutical products (Iodine, Thallium)

Mass activity (Bq/g)

EXEMPTED MATERIAL

EXCEPTED PACKAGE

TYPE A

Exemption value

EXEMPTED MATERIAL

Exemption value

10^{-n} A_1 or A_2

A_1 or A_2

Total activity (Bq)

Type B Packages

- **Examples:**

Research combustible packages

+

Industrial gamma graphic devices

Type B Packages shall be agreed by Nuclear Authority

Mass activity (Bq/g)

EXEMPTED MATERIAL

EXCEPTED PACKAGE

TYPE A

TYPE B

Exemption value

EXEMPTED MATERIAL

Exemption value

10^{-n} A_1 or A_2

A_1 or A_2

Total activity (Bq)

Industrial Type Packages

- **Examples:**

Concentrated Natural Uranium Transportation

Uranyl Nitrate Transportation

Industrial Packages

- **Contents:**

- **LSA Material (Low Specific Activity):**
  - ✓ **3 groups: LSA-I, LSA-II, LSA-III**
  - ✓ **Radioactive material which by its nature has a limited specific activity**

- **SCO (Surface Contaminated Object):**
  - ✓ **2 groups: SCO-I, SCO-II**
  - ✓ **solid object which is not itself radioactive but which has radioactive material distributed on its surface**

Industrial Packages

- **Examples and Definition:**

- **LSA Material (Low Specific Activity): Some examples**

✓ **Uranium and Thorium ores**

✓ **Isotopes with an unlimited A_1 or A_2 value**

✓ **Material in which the activity is distributed throughout and the estimated average specific activity does not exceed 10^{-5} A_2/g for solids and gases, and 10^{-5} A_2/g for liquids**

- **SCO (Surface Contaminated Object): Some examples**

✓ **Tools and Maintenance equipments/appartus**

✓ **Contaminated laundry**

- **Full definition could be found in Part 2, paragraph 7.2.3** (10.3.5 & 10.3.6)

Mass activity (Bq/g)

EXEMPTED MATERIAL

EXCEPTED PACKAGE

TYPE A

TYPE B

INDUSTRIAL (IP-1, IP-2, IP-3)

x A_2/g

Exemption value

EXEMPTED MATERIAL

Exemption value

10^{-n} A_1 or A_2

A_1 or A_2

Total activity (Bq)

Mass activity (Bq/g)

EXEMPTED MATERIAL

EXCEPTED PACKAGE

TYPE A

TYPE B

TYPE C

x A_2/g

INDUSTRIAL (IP-1, IP-2, IP-3)

Exemption value

EXEMPTED MATERIAL

Exemption value

10^{-n} A_1 or A_2

A_1 or A_2

3000 A_1 or 3000 A_2

Total activity (Bq)

Shipper's Responsibilities

➢ **Checking of the shipment :**

→ **Verification of the adequacy between substance and packaging**

☞ **can the substance be transported ?**

☞ **can the selected packaging contain this substance ?**

→ **Checking of the contamination**

☞ **it has to be maintain as low as possible and in each case, below the applicable mandatory limits**

→ **Checking of the radiation activity**

☞ **limited to 2mSv/h at contact, and 0,1 mSv/h at 1 meter**

→ **Transport Index calculation**

☞ **radiation quantification of a package/full shipment**

☞ **TI = 100 X dose rate at 1 meter**

Shipper's Responsibilities

➢ **Signalling the packages :**

→ **The risk presented by a shipment shall be clearly communicated as to**

☞ **protect the workers against the ionising radiations at all time**

☞ **inform the rescue teams in case of an accident/incident**

→ **Signalling is realized by**

☞ **marking of the packages**

☞ **labelling of the packages**

Shipper's Responsibilities

➢ **Labelling :**

→ **Different types of labels**

☞ **depending to the radiation activity of the package**

☞ **function to the dose rate at contact and to the TI (Transport Index)**

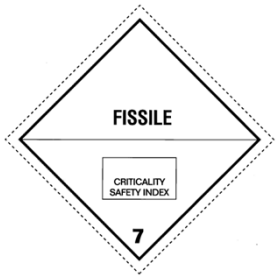
☞ **dedicated label for fissile material**

→ **Applicable for packages and overpacks**

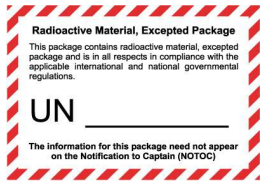
RRW

RRY

RRY



→ **For excepted packages "RRE" →**



Shipper's Responsibilities

- **Labelling :**

- **TI** (Transport Index) is dedicated to a package, an overpack or a freight container
- this number is used to provide the information on the radiation level

TI = 0

TI > 0
à ≤ 1

TI > 1
à 10

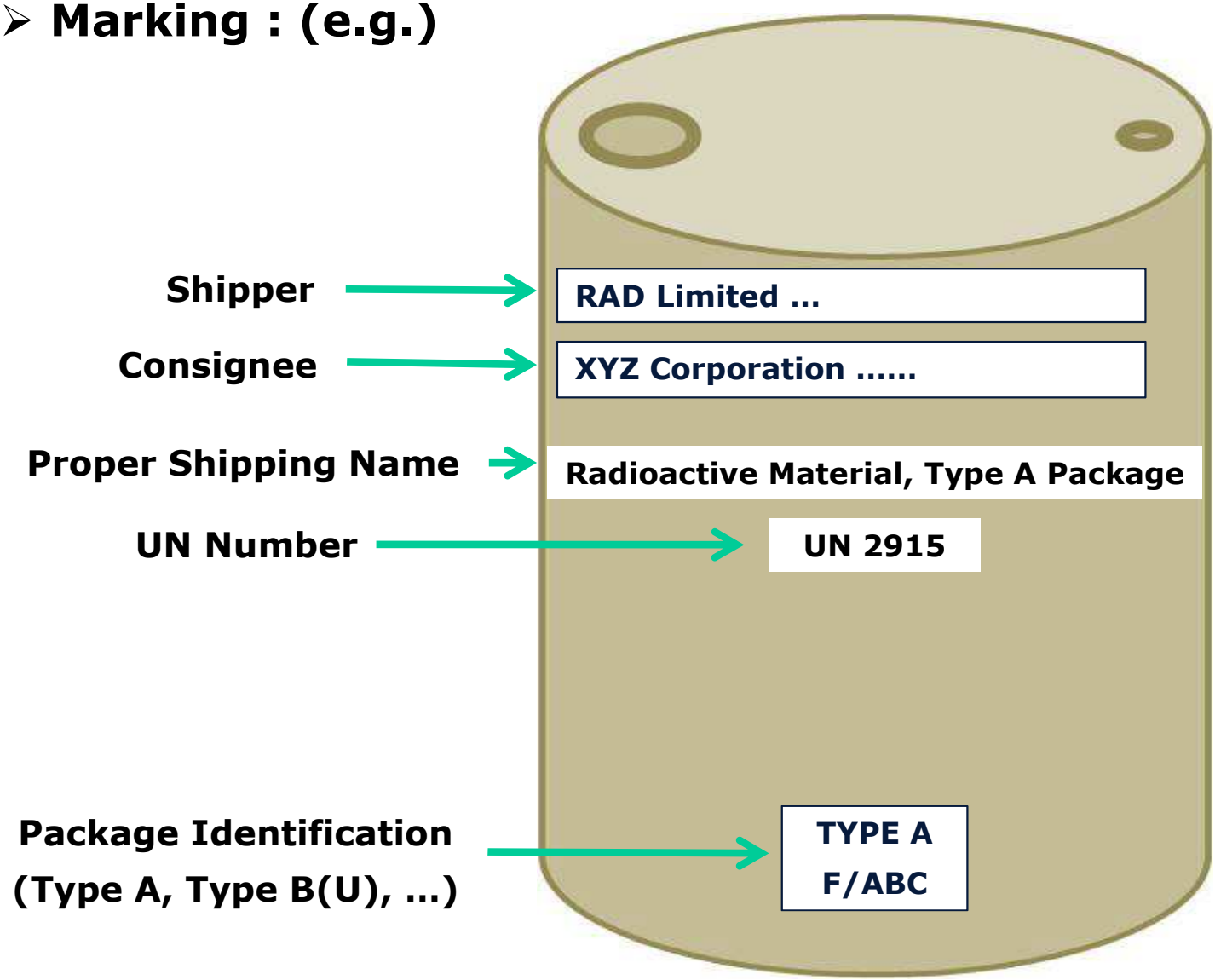
Shipper's Responsibilities

➢ Labelling :

Transport Index	Maximum radiation level at any point on external surface	Category	Label
0	≤ 0.005 mSv/h	I-White	
> 0 - ≤ 1	> 0.005 mSv/h - ≤ 0.5 mSv/h	II-Yellow	
> 1 - ≤ 10	> 0.5 mSv/h - ≤ 2 mSv/h	III-Yellow	
> 10	> 2 mSv/h - ≤ 10 mSv/h	III-Yellow, under exclusive use and special arrangement	

Shipper's Responsibilities

- **Marking : (e.g.)**



And also:

- Gross weight (if more than 50 kg)

- Serial number dedicated to the package in compliance with the agreed model

- Trefoil marking for Type B packages

Shipper's Responsibilities

- **Documentation : (e.g.)**

☞ **name and address of the shipper and the consignee**

☞ **UN number, proper shipping name, Class**

☞ **name or symbol of each radionuclide, description of the physical and chemical form of the material**

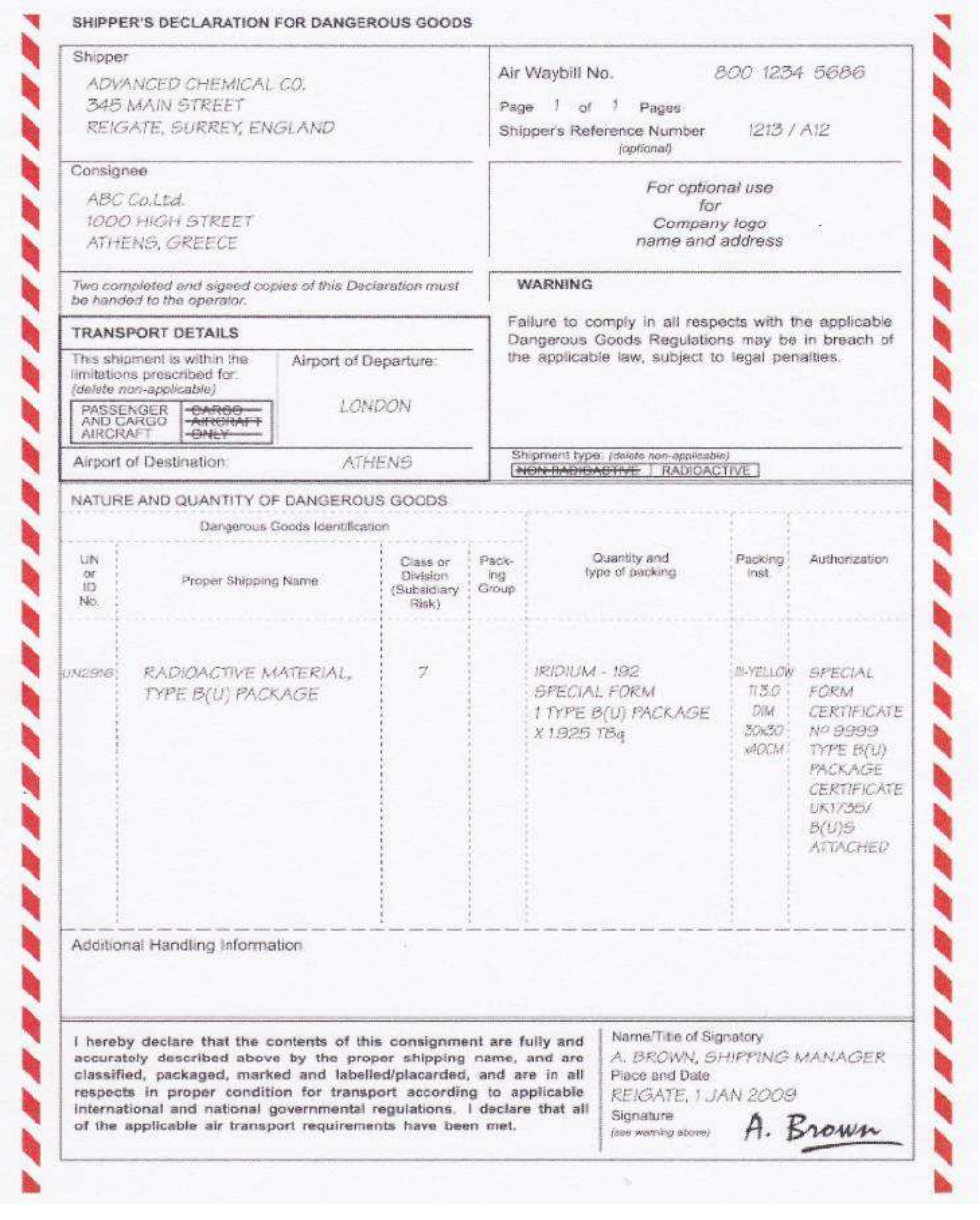
☞ **maximum activity of the radioactive contents, in becquerels (Bq)**

For fissile material, the mass of fissile material in grams (g)

☞ **category of the package, TI, CSI where applicable**

☞ **identification mark for each competent authority certificate of approval for the shipment**

☞ **where applicable, the statement "exclusive use shipment", LSA and SCO activity, …**



SHIPPER'S DECLARATION FOR DANGEROUS GOODS

Shipper
ADVANCED CHEMICAL CO.
345 MAIN STREET
REIGATE, SURREY, ENGLAND

Air Waybill No. 800 1234 5686
Page 1 of 1 Pages
Shipper's Reference Number (optional) 1213 / A12

Consignee
ABC Co.Ltd.
1000 HIGH STREET
ATHENS, GREECE

For optional use for Company logo name and address

Two completed and signed copies of this Declaration must be handed to the operator.

WARNING
Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties.

TRANSPORT DETAILS
This shipment is within the limitations prescribed for: (delete non-applicable)
PASSENGER AND CARGO AIRCRAFT ~~CARGO AIRCRAFT ONLY~~
Airport of Departure: LONDON
Airport of Destination: ATHENS
Shipment type: (delete non-applicable) ~~NON-RADIOACTIVE~~ RADIOACTIVE

NATURE AND QUANTITY OF DANGEROUS GOODS

Dangerous Goods Identification: UN or ID No.	Proper Shipping Name	Class or Division (Subsidiary Risk)	Packing Group	Quantity and type of packing	Packing Inst.	Authorization
UN2916	RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE	7		IRIDIUM - 192 SPECIAL FORM 1 TYPE B(U) PACKAGE X 1.925 TBq	II-YELLOW TI3.0 DIM 30x30 x40CM	SPECIAL FORM CERTIFICATE Nº 9999 TYPE B(U) PACKAGE CERTIFICATE UK1735/ B(U)S ATTACHED

Additional Handling Information

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 labelled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. I declare that all of the applicable air transport requirements have been met.

Name/Title of Signatory: A. BROWN, SHIPPING MANAGER
Place and Date: REIGATE, 1 JAN 2009
Signature (see warning above): A. Brown

EASA
European Union Aviation Safety Agency

Thank you for your attention

www.eu-sea-app.org

easa.europa.eu/connect

Your safety is our mission.

An Agency of the European Union