Manipulation of radio-isotopes: Radioprotection

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Regulatory framework

International

UNSCEAR
United Nations Scientific Committee on the Effects of Atomic Radiation

Collection data

ICRP – INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

IAEA – International Atomic Energy Agency

Recommendations & standards

Europe

Euratom

Establish regulations and directives.
Euratom 96/29, 97/43 and 2003/122

France

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

French law

asn – AUTORITÉ DE SÛRETÉ NUCLÉAIRE

Authority

ansm – Agence nationale de sécurité du médicament et des produits de santé

IRSN – INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

Expert

ANDRA – Agence nationale pour la gestion des déchets radioactifs

Objectives of the radioprotection

ICRP 103's principles of radioprotection:

1. Justification

You should always ask yourself if the use of radioactive material is needed or if experiment can be done with “cold” material

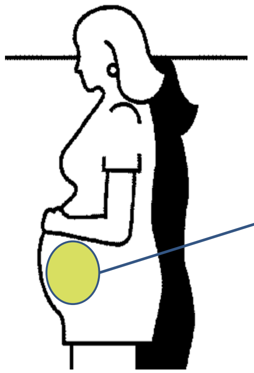
2. Optimization also called ALARA principle

Always ask yourself how I perform the experience and how I can improve it in terms of lower exposition (extremities, internal)

3. Limitation

Anyway, exposition must be lower than the regulatory limits so you must always wear your personal dosimeters to record any radiological exposition

Objectives of the radioprotection



	Annual dose limit for 12 consecutive months in France		
Organes	Public	Worker cat. A	Worker cat. B
Whole body	1 mSv	20 mSv	6 mSv
Extremities (hands, forearms, feet, ankles)	50 mSv	500 mSv	150 mSv
Skin surface 1 cm²	50 mSv	500 mSv	150 mSv
Crystalline lens	15 mSv	~~150 mSv~~	~~50 mSv~~

20 mSv next

1. Exclude deterministic effects by keeping doses below the known threshold

Example of a deterministic effect
Hand: dose > 3 Gy
Crystalline lens: dose > 2 Gy

2. Reduce stochastic effects for which there is no threshold by taking the linear hypothesis (radio-induced cancer)

General process

How to do: general process in which each personnel is involved

Terms radioactive sources

Sealed radioactive sources

- Calibration
- Research irradiation
- Irradiator (high activity)

Unsealed radioactive sources

- tracer
- Calibration
- Purchased or produced with a cyclotron

Unsealed activated radioactive sources

- Hot spot
- Material activated
- Cooling liquid

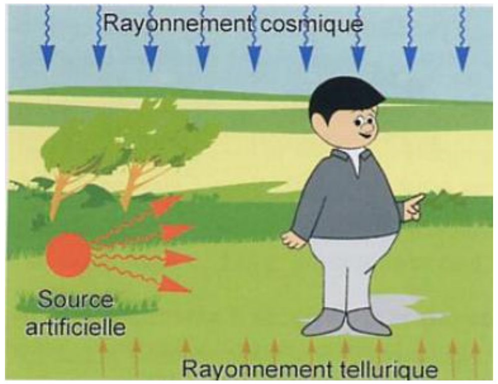
Research device

Cyclotron device

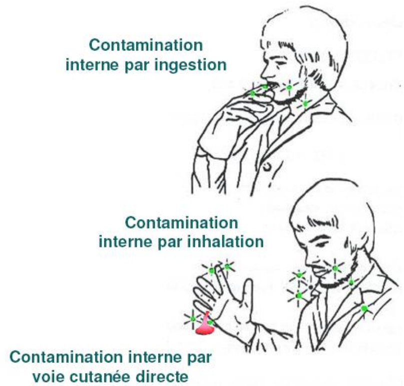
Risk analysis

Two types of risk

External exposition



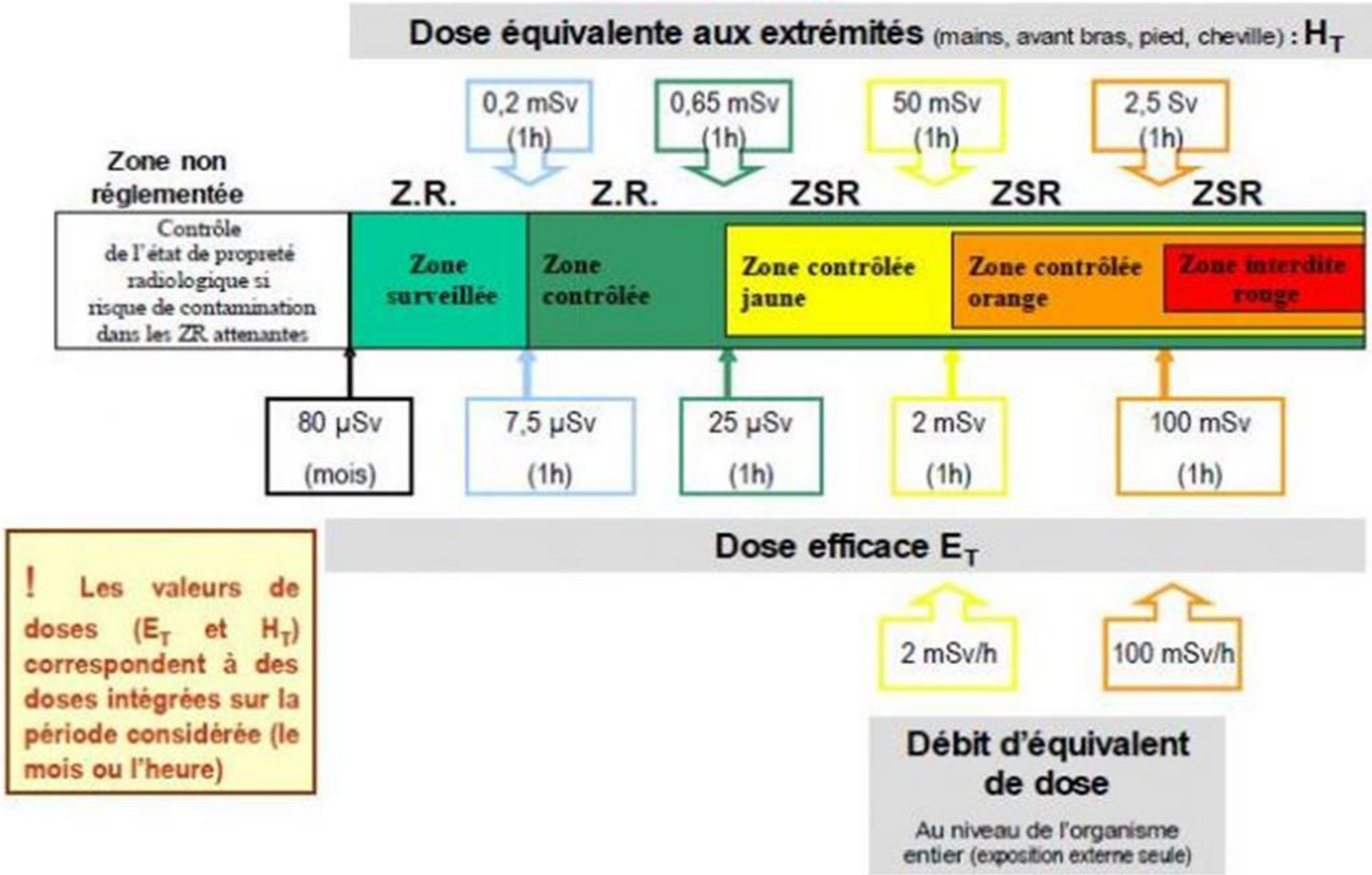
Internal exposition

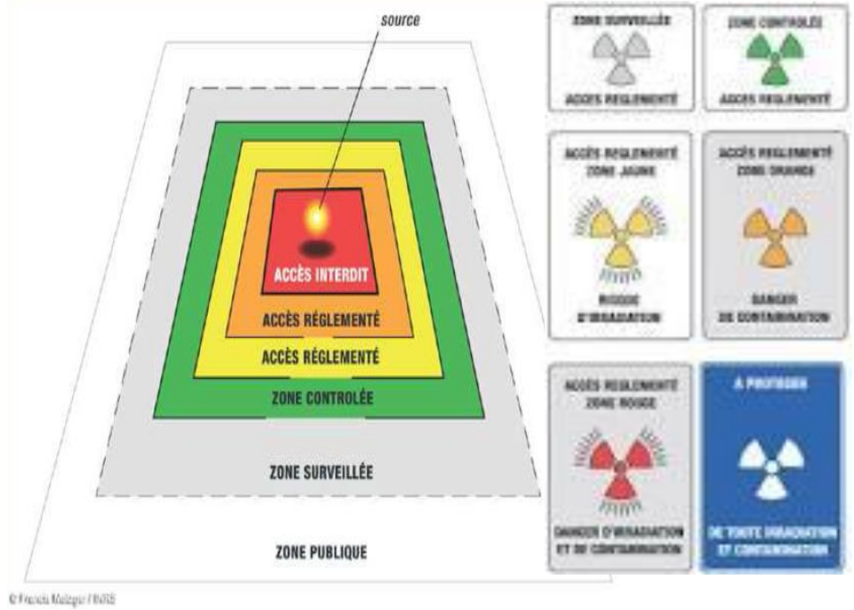


Three pratical rules

1. Time Proportional law		Exposition time reduction, optimize gestures NO improvisation!
2. Distance Inverse square law		Take distance with the source, use pliers NEVER take a source directly with hands!
3. Protective screen Exponential attenuation law		Heavy materials for γ and X, light materials for β, e- Depends on radiation type and its energy! Gloves are protective screen!

Radiologic zoning





Orange zone is prohibited for students

$$E \cong H_p(10) + E(50)$$ Must take into account external AND internal exposition

$$E(50) = \sum_j e_{j,inh}(50) \cdot I_{j,inh} + \sum_j e_{j,ing}(50) \cdot I_{j,ing}$$

Internal exposition considers both inhalation and ingestion (mishap)

Estimated dose

Calculation (simplified)

Internal exposition

Radioactive concentration (Bq/m^3):

$$C(t) = \frac{A_i \times k_i}{V} \times e^{-Rt}$$

A_i: activity manipulated (Bq)

k_i: volatility coefficient

V: volume of the working space (m^3)

R: room air change rate (vol/h)

Effective dose inhalation for 1 hour (Sv):

$$E_{inh.} = \frac{A_i \times k_i}{R \times V} \times (1 - e^{-R \times 1}) \times 1{,}2 \times \frac{DPUI_i}{p}$$

1,2 m^3/h: respiration rate

DPUI: dose per intake unit (Sv/Bq)

p: protective coefficient

External exposition

Effective dose for 1 hour (Sv):

$$E_{ext.} = B \times e^{-\mu x} \times \Gamma \times A$$

B: buildup factor

μ: attenuation coefficient (cm^{-1})

Γ : dose coefficient (Sv/Bq)

A: activity manipulated (Bq)

Risk analysis

Work area: V=1m3; air change rate=10v/h; d_{worker}=30cm; $d_{extremity}$=1cm

64Cu $T_{1/2}$=12,7h

10 MBq

Bench

P=1

E_{inh}=1,8 + E_{ext}=3,9 µSv/h
E_{eff}=5,7 µSv/h
E_{eq}= 3,51 mSv/h

+  5cm

E_{eq}= 141 µSv/h

100 MBq

Ventilated hood

P=0,1

E_{inh}=1,8 + E_{ext}=39 µSv/h
E_{eff}=40,8 µSv/h
E_{eq}= 35,1 mSv/h

+  5cm +  2cm Pb

E_{ext}=2,32 µSv/h
E_{eff}=4,12 µSv/h
E_{eq}= 1,41 mSv/h

1 GBq

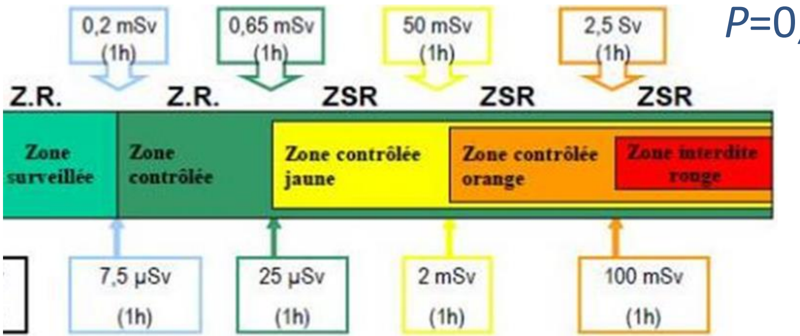
Gloves box

P=0,001

E_{inh}=0,18 + E_{ext}=390 µSv/h
E_{eff}=391 µSv/h
E_{eq}= 351 mSv/h

+  5cm +  2cm Pb

E_{ext}=23,2 µSv/h
E_{eff}=23,4 µSv/h
E_{eq}= 14,1 mSv/h



Risk analysis

Work area: V=1m3; air change rate=10v/h; d_{worker}=30cm; $d_{extremity}$=1cm

211At $T_{1/2}$=7,2h

Bench

P=1

E_{inh}=1,32 mSv/h + E_{ext}=6,8 µSv/h
E_{eff}=1,33 mSv/h
E_{eq}= 6,12 mSv/h

→ Max 180kBq

E_{inh}=23,8 + E_{ext}=0,12 µSv/h
E_{eff}=23,9 µSv/h
E_{eq}= 110 µSv/h

Ventilated hood

P=0,1

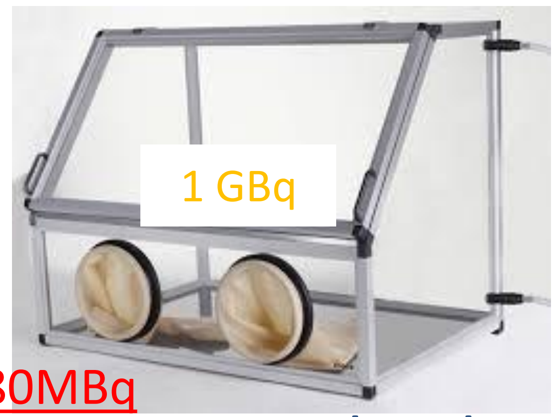
E_{inh}=1,32 mSv/h + E_{ext}=68 µSv/h
E_{eff}=1,39 mSv/h
E_{eq}= 61,2 mSv/h

→ +

5cm
+

2cm Pb

Max 1,8MBq
E_{inh}=23,8 µSv/h
E_{eff}=23,8 µSv/h
E_{eq}= 44,1 µSv/h



Gloves box

P=0,001

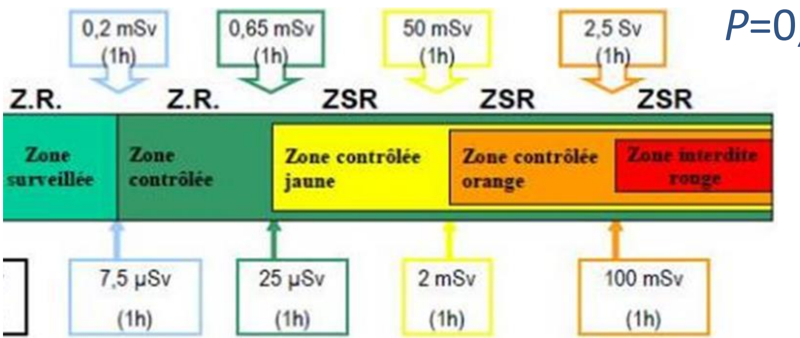
E_{inh}=132 + E_{ext}=680 µSv/h
E_{eff}=812 µSv/h
E_{eq}= 612 mSv/h

→ +

5cm
+

2cm Pb

Max 180MBq
E_{ext}=23,8 µSv/h
E_{eff}=23,8 µSv/h
E_{eq}= 4,41 mSv/h



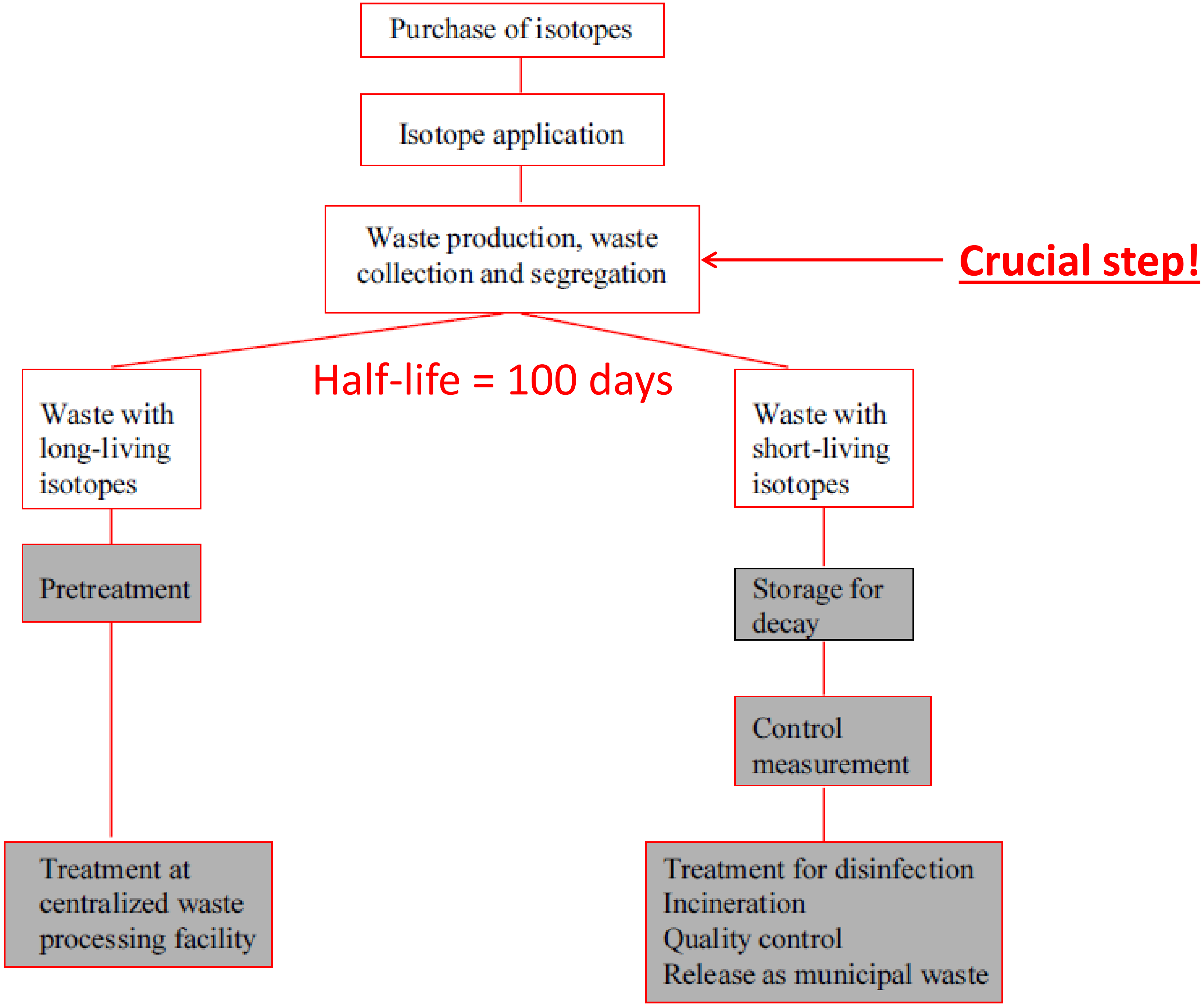
Radioprotection controls

NO contamination of the worker neither of the material → **CONTROL**

Contamination radiameter

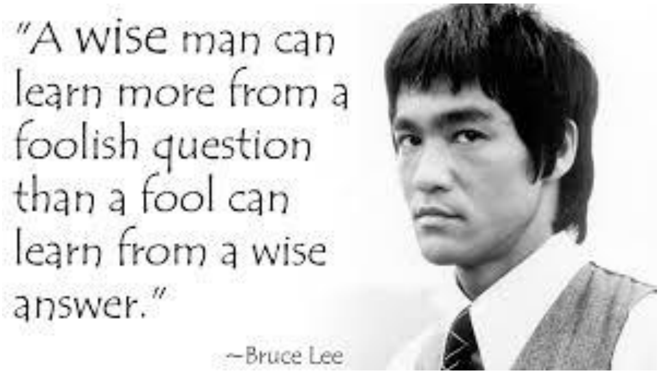
- Each experiment: at the beginning AND at the end
- Each time it's necessary or in any doubt of contamination
- Each exit of the controlled area

Radioactive waste management



In all cases…

- ✓ Please contact the competent department in radioprotection of your lab / institute
- ✓ You should receive a special training in radioprotection to show you the local rules
- ✓ Read the rules and respect it – never stay with a doubt or in a uncertain situation



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