IONIZING RADIATION

Sources

An atom is composed by a nucleus with electrons gravitating around it. Some atoms are unstable, are transformed spontaneously by releasing energy and then return to a stable state. They emit different types of radiation, and may carry an electrical charge (+ or – emission) or not (γ photons or X rays).

Sealed and unsealed sources ;
Natural source : source of ionizing radiation of a natural earth or cosmic origin ;
Unsealed radioactive source : source for which the presentation and normal conditions of use do not make it possible to prevent any dispersion of radioactive substances ;
Sealed radioactive source : source for which the structure or conditioning prevents, during normal use, any dispersion of radioactive matter into the surrounding environment.

Prior authorization must be obtained from the ASN (French Nuclear Safety Authority) in order to use ionizing radiation sources. Traceability for unsealed sources is provided through the existence of logs concerning incoming and outgoing radioactive substances, various inspections, etc.

Characteristics

• Radiation

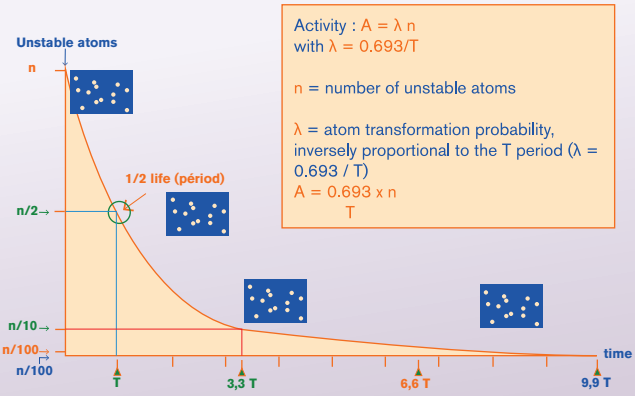
Transfer of energy in the form of electromagnetic waves or particles with a wavelength less than or equal to 100 nanometers.

- α low penetration, path of a few cm – stopped by skin or a sheet of paper ;
- β path of a few cm to a m – external exposure protection using Plexiglas if E ≤ 100 keV ;
- γ X path of a few m – substantial penetration – attenuated by shields (Pb, concrete) – no external exposure if E < 15 keV ;
- n path of a few hundred m – substantial penetration.

• T période

Time after which the initial activity is divided in half. The phenomenon decays exponentially.

Measurement and decay in the activity



Période : ^{11}C : 20 minutes ^{131}I : 8 days ^{33}P : 25,6 days
^{14}C : 5730 years ^{238}U : 4,47 milliard years
Residual activity after 10 T is less than 1/1000 of the initial activity.

The radioelement's effective period Te depends on the biological period Tb (elimination by the organism) and on the physical period Tp (nuclear disintegration).

The relationship between the 2 periods is as follows:
1/Te = 1/Tp + 1/Tb

carbon 14	Tp 5730 years	Te 10 days
tritium	Tp 12,3 years	Te 10 days

• Energy E unit : electron volts (eV - keV - MeV)
1 electron volt = 1.6. 10-19 joules
1 MeV = 1,6. 10^{-13} joules

• Activity A unit : en becquerel (Bq - kBq - MBq) nombre de désintégrations par unité de temps (ou transition/seconde)
1Ci = 3,7. 10^{10} Bq - 1 Bq = 27 pCi

Source of exposure

External : the source is at a distance or in contact and emits radiation ;

Internal : the radioactive source is incorporated into the organism through the skin and/or by inhalation and ingestion.

The dose received

- is proportional to the activity, energy of the particles, exposure time, period, and type of radiation ;
- is inversely proportional to the square of the distance 1/d2 (for radioelements used in biological research) ;
- depends on the exposure condition.

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External :

- at a distance: entire body or limbs (hands, forearm, etc.) ;
- through contact: handling materials containing a radioactive product, accidental deposit on the skin ;
- through immersion: in a radioactive atmosphere when manipulating gaseous radioactive sources.

Internal :

- by inhalation and through the eyes, digestive tract, skin and/or injury ;
- depends on the radioelement's physical-chemical form, the specific biological effects on the cell and the radiosensitivity of the exposed tissues.

◆ Dose

- **Absorbed dose noted as D, the unit is the gray Gy**
  Quantity of energy transferred per unit mass of the material 1 Gy = 1 joule.kg-1 ;
- **Equivalent dose noted as H, the unit is the sievert Sv**
  Absorbed dose x weighting factor Wr which takes into account the type of the radiation. For ß, γ, X radiations, Wr = 1 ;
- **Effective dose noted as E, the unit is the sievert Sv**
  Sum of the equivalent doses delivered to the various tissues, weighted by the tissue weighting factor Wt ;
- **Committed effective dose noted as E(τ), the unit is the sievert Sv**

For a worker, the equivalent dose integrated over 50 years after incorporation.

◆ Biological effects

The physical mechanisms for interaction between the particles and the matter primarily depend on the particle's mass and its energy.

- **Excitation** the transferred energy is less than the binding energy of the electron encountered ;
- **Ionization** the energy transferred is greater than that of the electron encountered :

- directly with α and ß ;
- indirectly with X and γ ;
- Emission of so-called **Bremsstrahlung** X-ray photon radiation during the interaction of an electron with a nucleus.

Premises and equipment

Handling premises : monitored or controlled areas.
The boundaries for the zones are set down by the Qualified Expert in Radioprotection (QER). The zone can be classed permanently or temporarily. In any case, it must be marked off. The zone can be reduced to a work station, e.g. : the biological safety cabinet in an L2 room.
Waste storage premises outside of the laboratory.
Protective equipment : fume cupboard, glove box, ß or γ shields.
Detection equipment : detectors suitable to the radioactivity measurement (radiations ß, γ, X), scintillation counters.

Gesture and equipment

The QER provides training for the personnel and informs them. The QER sets down the radioprotection rules and makes sure that they are indeed complied with - (workstation studies, instructions, controls, premises, waste, etc.).

The goal is to reduce :

external exposure : time, distance, shields (they stop ß radiation and reduce X and γ radiation) ;

internal exposure : personal protection equipment (PPE) as lab coat, gloves, goggles, etc.

Good practices: to elaborate an experimental protocol – to get training on gestures – regular non-contamination controls – to know the characteristics of the radioelements used.
To replace the radioisotope with a coloring agent of the fuchsin type before beginning a new manipulation.

Medical follow-up

	Public	Cat. A worker	Cat. B worker	Pregnant woman	Lactating woman
Entire body effective dose	1	20	6	1 mSv for the unborn child	0 mSv
Crystalline		150	45		
Limbs		500	150		
Skin (average dose, over 1 cm^2		500	150		

The personnel are ranked by the prevention doctor using workstation studies and the individual IR exposure sheet alongside the medical dossier, dosimetry results and the individual medical supervision form. This is followed by the setting up of external passive thorax and finger dosimetry, and even operational and internal via radiotoxicological analysis of urines.

Waste

A plan for waste and effluent management is requested in the authorization dossier and must make it possible to provide traceability for radioactive sources. This must take into account the radioactive period and the type of waste :

- Period < 100 days : initiation of decay, at least 10T – discharge > at 1.5 background noise – to take the way adapted to the risk at the end of decay ;
- Period > 100 days : removed by ANDRA.

The sorting and containers are based on the type of waste; liquid (aqueous or organic) - solid - mixed - gaseous.

In case of an accident

Keep quiet – inform the QER – follow the written instructions. In the case of a difficulty, contact the IRSN : **06 07 31 56 63**.

Material incident at the workstation
Mark off the contaminated zone. Absorb and decontaminate from the outside towards the inside. Check.

If a person is contaminated : give priority to treating medical-surgical emergencies.
Check, rinse with water for 10 minutes without rubbing. Inform the prevention doctor.