

RADIOACTIVITY AND NUCLEAR HAZARD

# Watc hris k



With the collaboration of the ANCLI

# The major risk formula

## HAZARD



Dangerous and unpredictable



## STAKES



Important and vulnerable



## MAJOR RISK



When an accident occurs, it is a disaster. The damage will be very important and the rescue teams will face many difficulties.



A power cut in a radiology clinic is not a major risk.



A long loss of heat removal while the nuclear power plant is in operation is a major risk.

# Spot the major accidents below.



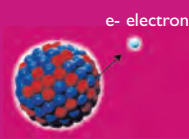
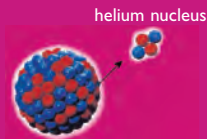
**Answers :**  
**Major accidents :** radioactive material transport accident (3), radioactive substances leakage into the environment (7).  
**Other situations :** daily life hazards (1, 4, 5 and 6).  
radiography incident (2).

# Radioactivity

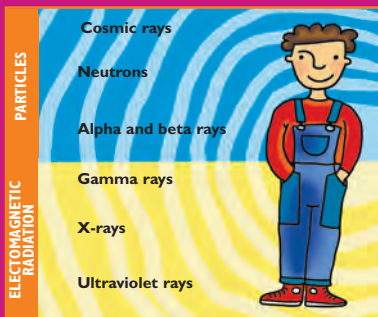
Matter is made of atoms. Some of these atoms are unstable and disintegrate while emitting different types of radiation : they are radioactive.

**Alpha decay ( $\alpha$ )**  
ex : uranium-238 atom

**Beta decay ( $\beta$ )**  
ex : carbon-14 atom



This radiation can be accompanied by a gamma decay ( $\gamma$ ).



Human beings have always been exposed to radiation in their environment.



In 4.5 billion years, natural background radiation has been divided by 4. As of today, it is still significant.



Since the beginning of the 20th century, human beings have created radioactive elements for various applications. It is the artificial radioactivity.

# In the following examples, does radiation come from natural or artificial radioactivity ?

Origins of radiation received by the population in France.



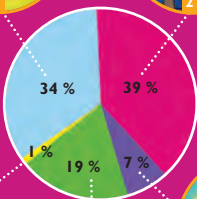
## Radon

This radioactive gas is emitted by some rocks (granite...) and by some construction materials.



## Medical exposure

Many x-ray exams are carried out each year.



## Technological activity

Releases due to the production of electricity, scientific research or nuclear military tests.



## Cosmic rays and telluric currents

Pilots and flight attendants dosimetry is monitored.



## Water, food and human body

Radioactivity is present in minerals, vegetables and animals.



In 1903, Henri Becquerel along with Pierre and Marie Curie share the Nobel Prize in physics for their discovery of natural radioactivity.



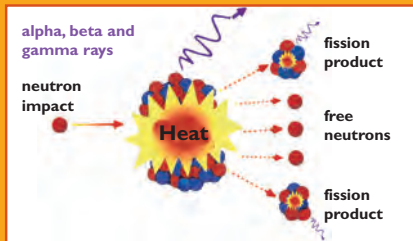
Artificial radioactivity applies cumulatively with natural radioactivity.

Natural radioactivity : 1, 4 and 5  
 Artificial radioactivity : 2, 3 and 5 if food releases.

Answers :

# From radioactivity to nuclear energy

7% of the electricity in the world is produced by 400 nuclear reactors. 80% of the electricity in France is produced by 58 nuclear reactors spread over 19 different sites.



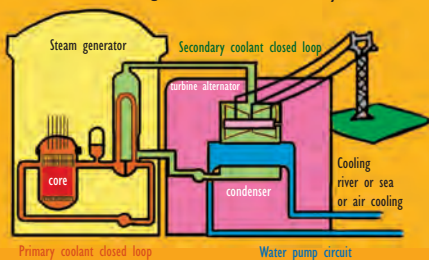
The nuclear fission reaction is induced by the bombardment of the atoms with neutrons. It subsequently generates heat energy.



Fission products, such as cesium, iodine and strontium are highly radioactive waste which can contaminate the environment. They are stored temporarily, waiting to be sent to final disposal facilities.

Containment building

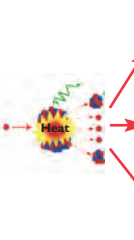
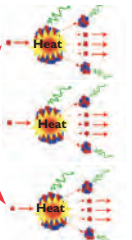
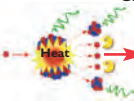
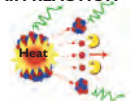
Production of electricity



In the nuclear reactor core, the fission of uranium 235 is under control thanks to control rods able to absorb the neutrons. The heat liberated by the fission must be constantly removed by the coolant loops.

A long loss of heat removal will lead to a major accident. The containment building must always remain leakproof.

**In the following examples, how many neutrons will be released at level 3 ?**

Level 1	Level 2	Level 3
<b>FIRST CASE : FISSION CHAIN REACTION</b>		
		<p>&gt; 9 ?</p> <p>&lt; 9 ?</p>
<b>SECOND CASE : CONTROLLED CHAIN REACTION</b>		
		<p>1 ?</p> <p>3 ?</p>

**One failure of the system and the core is out of control !**



In 1986, a reactor at the Chernobyl nuclear power plant exploded in Ukraine. A WHO\* report from 2006 stated that :

- 30 people died in the 15 days following the disaster,
- thousands of people (between 9 000 and

16 000) will die in the 50 years following the disaster. Diseases and deaths are caused by the contamination of the soil, air and water. Belarus, a neighbouring country, was particularly affected.

\*WHO : World Health Organization

First case : more than 9 released neutrons  
Second case : 1 released neutron

**Answers :**

# Fukushima : Chaos

## From a natural disaster ...



March 11, 2011, the northeast coast of Japan is shaken by an earthquake of magnitude 9. It causes a tsunami that ravages the seafront with waves sometimes higher than 10 meters. Many aftershocks follow for weeks.

## ... to a nuclear accident ...



The protective dyke of the Fukushima Daiichi nuclear power plant is flooded. Cooling systems of reactors are destroyed. 3 out of 6 cores melt.



The population is evacuated up to 30 km around the plant, due to radioactive releases.

## ...and to contamination



Assumptions, calculations and field measurements define :

- the radioactive plume,
- contamination,
- assessment of "received and future" doses by the population.



The Operator, the Japanese authorities and the population will have to manage long-term site, contamination and health risks.



# Radiation is used for :



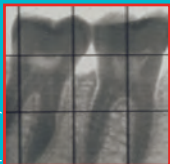
**Sterilising food** to improve its preservation. Food is irradiated with **gamma rays**.



**Baggage screening.** X-ray device let you see the content.



**Dating relics.** It involves the measurement of **alpha and beta rays** from radioelements such as **carbon-14, uranium/thorium...**



**Diagnosing and treating** some diseases of the human body.

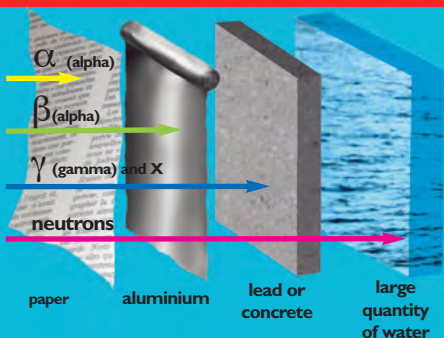
photos by CEA



**Watch out :**

Daily exposure to this radiation is dangerous. That is why workers are protected by radiation shields.

**In the following examples, which matter will protect you from the radiation ?**



**Case #1 :**

You are screening baggage in an airport.

You are shielded by an apron made of

**Case #2 :**

You are working in a nuclear power plant.

You are protected from neutrons

- emitted by fission products by

in the spent fuel pool.

**Case #3 :**

In hospitals,  $\alpha$  (alpha) and  $\beta$  (beta)

radiological sources are stored in boxes

made of

**Case #4 :**

You are operating a food irradiation

device. You are protected by the irradiation

chamber walls made of

**Answers :**

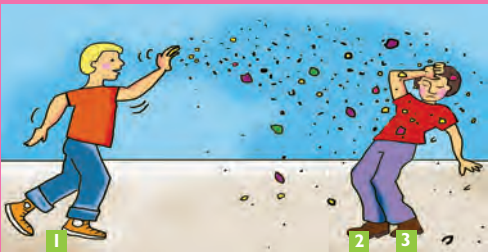
Case #1 : lead

Case #2 : large quantity of water

Case #3 : lead

Case #4 : concrete

# The 3 radioactivity measurement units



**1 ACTIVITY** (illustrated by the number and size of the thrown stones) is the intensity of the radiation emitted by the source. It is measured in **becquerels**.

**2 ABSORBED DOSE** (illustrated by the number and size of the stones hitting the boy) indicates the quantity of radiation absorbed by the individual or the matter. It is measured in **grays**.

**3 DOSE EQUIVALENT** (illustrated by the boy's scrapes and bruises) indicates the biological effects on a body exposed to radiation. It is measured in **sieverts**.



Radioactivity can't be felt. Special measurement devices are needed to quantify radioactivity. A dosimeter measures a worker's exposure to the radiation.



The maximum exposure rate allowed is specified by specialists. For instance, as a precaution, the International Commission on Radiological Protection considers that the artificial radiation measured on any person should not exceed 1 millisievert per year.

# Knowing is understanding the major risks



- Most countries inform the Public by :
- Internet
  - Brochures
  - Posters
  - Public meetings
  - Documentation

E.g. in France : A local major risks file is available for consultation at the local authority. The city information document on the major risks (DICRIM). The local information committees (CLI) communicate with the population over the nuclear installations activities.



To learn more about nuclear hazards and about the different keyplayers involved surf on the IAEA website or on your national official websites e.g. in France :

[www.prim.net](http://www.prim.net)

[www.irsn.fr](http://www.irsn.fr)

[www.acro.eu.org](http://www.acro.eu.org)

[www.asn.fr](http://www.asn.fr)

[www.ancli.fr](http://www.ancli.fr)

[www.cea.fr](http://www.cea.fr)



Spatial planning

Monitoring

Planning

Education

Knowing

Information

Self protection

## Mitigation

Every effort to reduce the effects of a disaster adds to sustainable development of our territory.

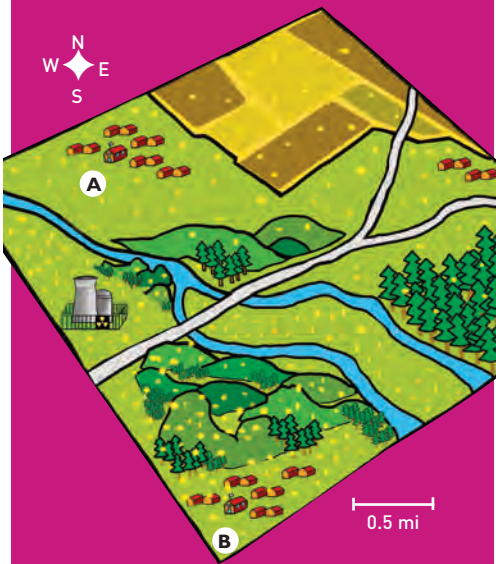
# Where do procedures apply ?

A release of radioactive elements occurred at the power plant. The alarm siren has been activated.

According to the contamination map :

1 - What are the zones where people should seek shelter ?

2 - In your opinion, why is village B particularly contaminated ?



**Answers :**  
1 - In the immediate surroundings of the plant, all the people must seek shelter.  
2- Under some weather conditions, the wind can carry the radioactive cloud in any particular direction. On the picture, the wind comes from the north-west and blows toward the south-east. So, contamination is higher in village B.

# Emergency plans and procedures to be prepared :

Together, we are better prepared to face a nuclear accident.

## At school :

The Specific School Safety Plan explains students and staff members of an educational institution how and when to shelter or to evacuate safely.

Parents are informed about the emergency plan and are told that they must never "pick up their children from school" throughout the duration of the alert.



## In the city

A city emergency plan reviews the means of protection and activates them in the case of a major emergency.

## In the area around a high-risk industry

A specific intervention plan is triggered by the local authority at department level in order to protect the population. It rallies and coordinates the State services and the emergency rescue teams.



Simulation-based exercises are necessary to test the efficiency of these plans. They also teach you how to react in case of an accident.

# You are hearing the national alert siren... What will you do next ?



I open the window to take photos.



I quickly stock up with bottled and tap water pending a potential contamination.



I ensure that all windows in the house are well closed and I listen to the radio.



I call my friends to tell them about the accident.



I look for the iodine pills or syrop to have them at hand in case the officials tell me to take them.

**Answers :** Yes, you should : 2, 3 and 5  
No, you must not : 1 and 4

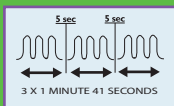
# Safe and sheltered

When there is a radioactive cloud, the National Alert System (NAS) will warn you. It means that you have to take shelter inside a building.



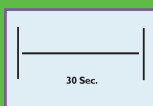
## ALERT

discontinuous sound



## END OF ALERT

continuous sound



In France you can listen to the NAS sound on this website : [www.iff-rme.fr](http://www.iff-rme.fr)



Vehicles equipped with a siren relay the alert.

By a nuclear accident always listen to the instructions given by the authorities on the Radio.

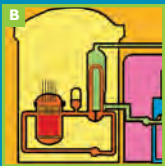
Use a battery-powered radio in case of a blackout.



The local authority at department level decides when the iodine pills or syrup are to be taken. He can also issue an evacuation order for the population or keep them at home and give them specific instructions.



# Spot the misplaced pictures.



BEFORE

Nuclear plant workers are regularly trained.

3 safety barriers protect each nuclear reactor to avoid any risk of radioactive leakage :  
the fuel cladding, the reactor vessel and the containment structure.

DURING

A warning system to warn the population if a major accident occurs.

The population is evacuated from a highly contaminated site.

AFTER

Living in a contaminated environment implies changing habits :  
not consuming certain products...

**Answers :**  
Pictures A, C and D are misplaced.  
The correct order is : C, B, D, A, E

# Taking action to :

- avoid a major accident,
- manage emergencies to immediately limit their consequences,
- allow the society to progressively go back to a normal life.



PREVENTION

Laws regulate the operation and the storage of radioactive materials.

A regular monitoring of the radioactivity is performed in and around nuclear installations.

DURING

On a contaminated site, an emergency team dressed in protective gear brings assistance to the population.

Following official instructions, each person must take an iodine pill to diminish the impact of a radioactive cloud on Public Health. Certain countries even have Iodine syrup for children.

AFTER

Cleanup of the contaminated soil can facilitate the return of an evacuated population. Highly polluted soils and objects will be considered as radioactive waste.

# Fukushima : Consequences



## Human

Thousands of people were evacuated and relocated. Others are forced to adapt to live in contaminated areas. Health effects will be revealed in the future.



## Environment

Soils and marine ecosystems are contaminated. Vegetables, fruits and animals are unfit for human consumption.



## Economy

The local economy disappears around the nuclear power plant. The country's financial growth stops for several months.



## Politics

Nuclear energy, safety, emergency response management, risk prevention and public information are subject to debate in many nuclear nations.



Air is monitored on all continents to alert the population in case of significant radioactivity.

# Internal or external contamination ?

In a contaminated zone...



I eat mushrooms picked by my neighbour.



I roll on the lawn.



A cow grazes in the field nearby. I drink the milk from the cow.



I play ball in the street.

**Answers :**  
Internal contamination :  
Cases #1 and 3  
External contamination :  
Cases #2 and 4. If the air is also contaminated, there will be internal contamination as well in these cases.

# Irradiation and contamination



By a major nuclear accident, fission products are released and spread in the air. They form a radioactive cloud composed of gas, drops and dust.



When the radioactive cloud, caused by the nuclear accident, is above me, I'm irradiated by ionising radiation.

When the radioactive cloud is gone, the fallout (dust and drops) remains and fission products are all over my body, my clothes and the environment. Everything is contaminated.



Contamination occurs through inhalation, ingestion or contact.



Conception graphique : Isabelle Cochereau, conception éditoriale : IFFO-RME / 2011



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collaboration  
of the ANCLI



# watch risk

RADIOACTIVITY AND NUCLEAR HAZARD