AUTORITÉ DE SÛRETÉ NUCLÉAIRE

National Guide
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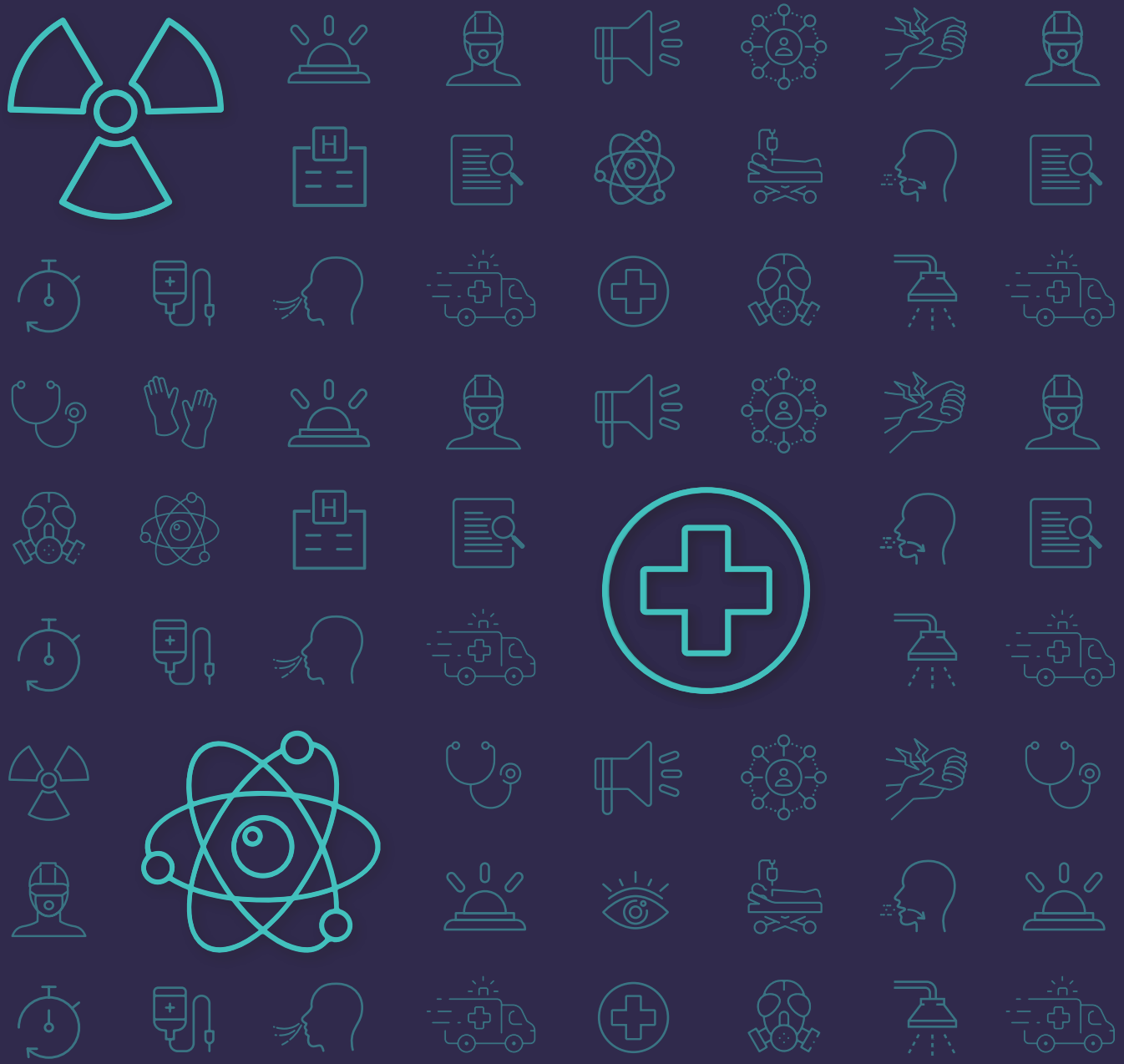
MEDICAL RESPONSE IN A NUCLEAR OR RADIOLOGICAL EMERGENCY



MEDICAL RESPONSE IN A NUCLEAR OR RADIOLOGICAL EMERGENCY

National Guide

2023 ISSUE

The 2023 issue of the national guide "Medical Response in a Nuclear or Radiological Emergency" is a fully revised version. It builds on the official reference documents and instruments:

- Contingency plans such as the regional application of the governmental Chemical, Biological, Radiological or Nuclear (CBRN) plan or the Off-Site Emergency Plans;
- The medical management aspects: Circular 800[1] and the Major Radiological or Nuclear Accident National Response Plan activated by the Prefect.

The recommended actions are to be adapted according to the situations and the available resources. The emergency treatments listed are essentially the initial first aid measures to take so that the specialists can subsequently administer the appropriate treatments.

In the majority of cases these emergency treatments are carried out by the Mobile Emergency and Resuscitation Service (SMUR) and the Rapid Response Health Units (RRHU) of the Fire and Rescue Service (FRS) in the field or in hospital in the emergency or intra-hospital structures (imaging, operating theatre, etc.) or in the occupational health services.

The emergency therapies proposed in this guide, particularly in the case of internal contamination, which are based on the current state of knowledge, use medicines that have a marketing authorisation (MA) or are undergoing studies with a view to obtaining this authorisation issued by the French Health Products Safety Agency (ANSM). Furthermore, stocks of some of these products have been acquired insofar as possible and distributed nationally for use in the pre-hospital and hospital environments.

The update was carried out as part of the work of the Advisory Committee of Experts in Radiation Protection (GPRP) and the French Nuclear Safety Authority (Autorité de sûreté nucléaire – ASN).

CONTRIBUTING EXPERTS listed in alphabetical order

Members of the working group

- **P. Barbey** *(University of Caen Normandie)*
- **Ph. Bérard** *(CEA)*
- **L. Bodin** *(CEA)*
- **S. Bohand** *(Orano)*
- **G. Bonardel** *(Centre cardiologique du Nord – North Cardiological Centre)*
- **M. Bourguignon** *(Paris Saclay University – UVSQ)*
- **C. Challeton-de-Vathaire** *(IRSN)*
- **J. Fogelman** *(Quatre Villes Hospital)*
- **G. Gagna** *(SPRA)*
- **F. Ménétrier** *(CEA)*
- **JM. Philippe** *(General Directorate for Health – DGS and SGDSN)*
- **Ph. Sans** *(SIS 31)*
- **D. Schiedts** *(Cotentin Public Hospital)*
- **C. Telion** *(SAMU 75)*

Reviewers

- **S. Abdelkhalek** *(Rouen University Hospital)*
- **JC. Amabile** *(SSA)*
- **C. Bertrand** *(Henri Mondor AP-HP Hospital)*
- **A. Bonnin-Dussaud** *(SSA)*
- **A. Cazoulat** *(SSA)*
- **M. Deloy** *(Henri Mondor Aurillac Hospital)*
- **E. Delvecchio** *(General Directorate for Health – DGS)*
- **M. Deschouvert** *(Rouen University Hospital)*
- **C. Dolard** *(Rouen University Hospital)*
- **F. Entine** *(SSA)*
- **V. Fofana** *(General Directorate for Health – DGS)*
- **L. Gabilly** *(Civil Hospices of Lyon)*
- **Y. Ibanez** *(General Directorate for Health – DGS)*
- **L. Lachenaud** *(SGDSN)*
- **M. Lamballais-Glemot** *(Rennes University Hospital)*
- **JB. Le Loch** *(National Civil and Military Centre for NRBC-E Instruction and Training – CNCMFE NRBC-E)*
- **A. Raynaud-Lambinet** *(CNCMFE NRBC-E)*
- **S. Supervil** *(SGDSN)*
- **J. Treille** *(Nîmes University Hospital)*
- **E. Vial** *(SGDSN)*

Previous issues:

1997: *Initial version produced by a working group of the Scientific Council of the Office for Protection against Ionising Radiation (OPRI)*

2002: *1st update coordinated by ASN*

2008: *2nd update coordinated by ASN*

1. Circular relative to the national doctrine concerning the use of emergency and medical care resources in the event of a terrorist attack involving radioactive materials.

PREFACE

A PRACTICAL GUIDE FOR ALL PARTICIPANTS IN MEDICAL EMERGENCY SITUATIONS

Do you work for the Emergency Medical Assistance Service (SAMU), the Mobile Emergency and Resuscitation Service (SMUR) of the Fire and Rescue Service (FRS)? Do you work for the headquarters of a defence zone or a hospital emergency department? Are you an occupational physician, a first-aid rescue worker or an instructor?

This national medical response guide is intended for all health and civil security actors who could be required to respond to a nuclear or radiological emergency. It essentially covers the initial measures to take so that the specialists can subsequently apply the appropriate treatments.

This third update of the national guide incorporates the organisational changes that have come about since 2008 and the new contamination treatment protocols and means. Coordinated by ASN, the French Nuclear Safety Authority, this update was carried out by a working group chiefly comprising emergency physicians and experts in radiation protection, internal dosimetry and radiotoxicology.

In the context of its duties, ASN contributes to the management of nuclear or radiological emergencies and advises the Government. As such it plays a leading role in preparing for radiological emergency situations.

The 2023 issue of this reference guide is based on a study of practices with professionals in the field which has enabled their expectations to be more clearly identified. The guide has been completely reorganised to meet the needs and utilisation contexts of the addressees. It takes the form of operational sheets on which the relevant information for any situation can be found quickly to ensure a fast response: treatment in the event of irradiation, action to take in the event of contamination and technical sheets (procedure for removing clothing, means of protection, etc.). It also includes the possible treatments and dosage for each radionuclide.

The guide is available primarily in digital format on the ASN website. Don't hesitate to spread the work among your colleagues!

We hope you enjoy reading it!

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C
Cadmium ..... RH 9
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Cerium ..... RH 13
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E
Erbium ..... RH 18
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F
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G
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SHEET 01

MEDICAL RESPONSE STRATEGY

The 7 essential principles

The exposure of people to a radiological or nuclear (RN) agent can result from an accident, a terrorist attack or an act of war. The medical response aims to evaluate the severity of the condition of the victims, to define response priorities and to consider the use of antidotes after evacuation of the victims by the emergency response teams. The emergency decontamination and full decontamination measures limit the radiological risk and the transfer of contamination into the healthcare facilities outside the contaminated area. Medical-surgical urgencies take priority over the treatment of contamination and irradiation.

RADIOLOGICAL OR NUCLEAR EVENTS

They can be caused by:

- **accidents**: nuclear industry, radiotherapy devices, transport of radioactive substances, laboratory accident, etc.
- **terrorist attacks**: attack by an explosive agent with dispersion of radioactive substances ("dirty bomb"), dispersion of radionuclides into the environment, exposure to a high-activity sealed source, etc.
- **acts of war**: utilisation of tactical nuclear weapons, etc.

These RN events involve a risk of radioactive contamination and irradiation of a large number of victims.

Medical-surgical urgencies take priority over the treatment of contamination and irradiation

A human being can be irradiated or contaminated by a radioactive source. Irradiation results from exposure to a source external to the organism, while contamination can be either external (skin, hair, beard, clothing) or internal. Contamination causes irradiation throughout the time the radionuclide is present.

Whatever the situation, medical-surgical urgencies take priority over the treatment of contamination and irradiation. The urgent medical actions must therefore be taken using appropriate techniques before carrying out full decontamination.

SEE SHEET 3

Radioactive contamination does not usually have immediate effects

A person is contaminated if radioactive particles are deposited on their **skin, skin appendages** (such as hair, beard, nails) or **clothing** (external contamination) or if these particles enter the organism by **ingestion, inhalation** or **further to skin puncture**, or possibly **penetrating injuries** (internal contamination).

The absence of immediate effects complicates the evaluation and the treatment of potentially exposed persons.

SEE SHEET 3

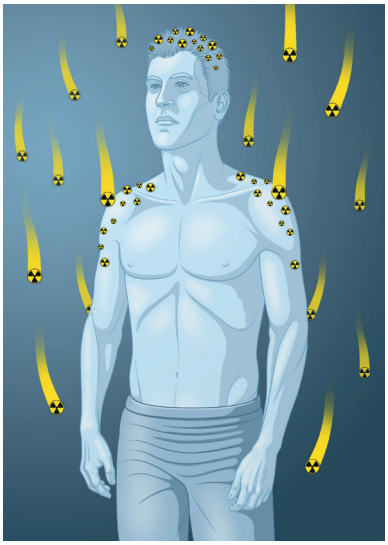
The external contamination was caused by the deposition of aerosols, dust or liquids

The external contamination of a person comes from deposits on the **skin, clothing** and/or the **skin appendages**, such as hair, beard and nails).

Decontamination is carried out by **undressing and washing the exposed persons**, in one or two steps: emergency decontamination, followed by full decontamination.

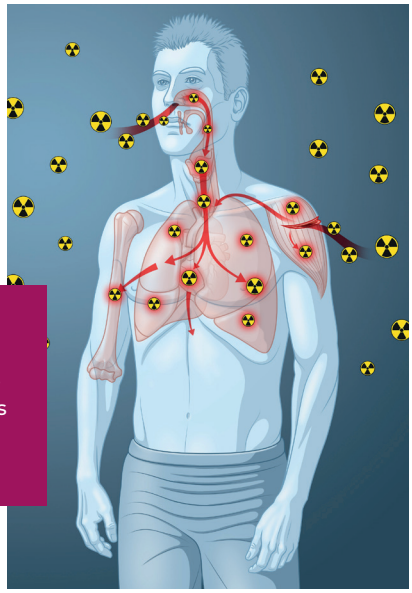
Protecting the upper airways as soon as possible prevents external contamination from being transformed into internal contamination (instructions: do not drink, eat or smoke).

SEE SHEET 7



In the event of internal contamination, antidotes must be administered as soon as possible

In the event of internal contamination, the radioactive elements are stored in different organs depending on their chemical nature.



Internal contamination results from the entry of radionuclides into the organism. When a radionuclide is incorporated in an organism, it irradiates the tissues for a time that varies according to the physical half-life of the radionuclide and its biological retention in the organs. This is the committed effective dose.

The radioactive substances causing the exposure are incorporated in the organism by ingestion, inhalation or after skin puncture (piercing, injury, penetrating wound). The subject then becomes exposed by internal contamination. Once the substances are incorporated, they can accumulate in certain organs (such as the thyroid in the case of radioactive iodine and the bones in the case of strontium).

Emergency treatment with antidotes aims to prevent storage of the contaminant in the tissues or to speed up its natural elimination. Administration of antidotes reduces the quantity of radioactivity retained in the organism and hence the dose received by the tissues/organs and the risk of radiation-induced cancer.

SEE SHEETS 7 27 + 38 to 40 + radionuclides handbook

In prehospital situations, a nuclear or radiological medical emergency requires a specific response framework

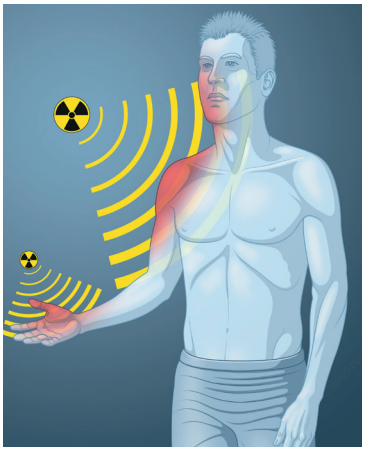
"**Nuclear**" covers anything that concerns the properties of the nuclei of atoms and radioactive materials.

"**Radiological**" covers aspects concerning radiographic imaging techniques and events causing exposure to ionising radiation.

The nuclear or radiological emergency response teams must be suitably trained and have Personal Protective Equipment (PPE) that is appropriate for the risk and the intervention site. The exposure of responders is evaluated by personal monitoring using passive and active dosimeters and, if necessary, by bioassay measurements (*in vivo* analyses and *in vivo* measurements).

SEE SHEETS 6 22

An irradiated person does not irradiate others any more than a burned person burns others



Irradiation results from exposure to ionising radiation: the radioactive source is situated outside the body and the radiation passes through the organism or part of it.

The irradiation is said to be external. The person stops being irradiated once they are sufficiently far from the source. The person does not transport any radioactivity but suffers the effects caused by the radiation.

The exposure must be confirmed and characterised, and its severity must be evaluated as quickly as possible.

SEE SHEETS 5 11

IRRADIATION

The radioactive substances or the ionising radiation emitter causing the exposure are/is situated outside the organism:

- **either at a distance from the body,** leading to overall exposure of the organism;
- **or close to the body,** leading to localised exposure.

In both cases, we use the term **irradiation**.

The risk of contamination being transferred from a deconta-minated victim is negligible

The usual work dress of hospital personnel provides adequate protection: **gown, gloves and surgical mask.**

SEE SHEETS 6 30

SHEET 02

MEDICAL RESPONSE STRATEGY

General conditions of response

Medical-surgical urgencies take priority over the treatment of contamination and irradiation: this principle applies whenever responding to a radiological or nuclear (RN) emergency, whether it involves one or more victims. As for the medical response strategy, it must comply with the criteria set out below.

15
17
18
112

Mutual exchange of information between emergency services

The information must be exchanged mutually between the emergency response and the emergency medical services (there are four different emergency service phone numbers in France: 15 (SAMU), 17 *(Police/Gendarmerie)*, 18 (Fire Brigade) and 112 (European emergency number). These services trigger their respective response means according to pre-established contingency and emergency care plans (defining of a First Destination Area (FDA) and a Resources Assembly Area (RAA).

Sending of a trained and equipped medical team

After medical regulation and confirmation of the nature of the event (explosion, chemical accident, etc.), sending a trained and equipped medical team enables urgent medical and resuscitation treatments to be ensured without delay. This team has active dosimeters for the persons potentially exposed to radiation.

Medical monitoring of the response actions

The regulating physician of the regionally competent Emergency Medical Assistance Service (SAMU) ensures the medical monitoring of the response. He or she refers in particular to this *"Medical Response Guide for Nuclear or Radiological Emergencies"*.

Depending on the scale of the event, a physician capable of fulfilling the functions of Medical Operational Coordinator (MOC) may be sent to the site to manage the event in collaboration with the zone SAMU.

Intervention of a SMUR team trained for the RN risk

A team from the Mobile Emergency and Resuscitation Service (SMUR) or the Rapid Response Health Unit (RRHU) trained for the RN risk intervenes, assisted if necessary by a specialist in nuclear medicine and a Radiation Protection Expert (RPE) from the same facility or, if necessary, a person from the Regional Reference Hospital for the RN risk (RRH RN).

Inter-personnel collaboration

It the intervention takes place on an industrial site classified as representing a "radiological or nuclear risk" (such as the nuclear power plants), there must be effective collaboration between the medical team and the personnel present on the site, especially the occupational medicine and radiation protection personnel.

Scaling up the response organisation

Scaling up of the response organisation must be considered on the basis of the situation assessment established by the first medical team on the site in collaboration with the zone SAMU and the RRHH RN.

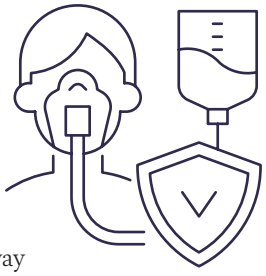
SHEET 03

MEDICAL RESPONSE STRATEGY

Action priorities along the medical care pathway

The radiological or nuclear (RN) emergency is likely to lead to irradiation and/or external and/or internal contamination. Whatever the extent of any such contamination and the stage of treatment, medical-surgical urgencies take priority over contamination and irradiation management once medical care is provided on the site of the event.

1 Vital actions and protection of injured persons against radioactive exposure



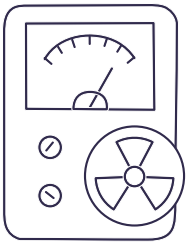
Appropriate resuscitation measures and emergency techniques must always be applied immediately on the site of the event.

Protection against internal contamination
Protecting the victims against internal contamination is a reflex action, in the same way as the resuscitation actions. The aim is to protect the airways without delay (wipe the face with a damp compress and put a medical face mask on the victim).

Resuscitation actions and transfer to a safe place
The resuscitation actions are performed on reaching the Victim Assembly Area (VAA), in the controlled area, without delaying transfer of the most critical victims (medical regulation).

SEE SHEET 17

2 Protection of responders



Only suitably trained and physically prepared rescue service or emergency medical teams can respond in radiological emergency situations. They must be protected against the risk of external and internal contamination by protective equipment that is appropriate for the zone concerned and they must wear active and/or passive dosimeters. SEE SHEET 16

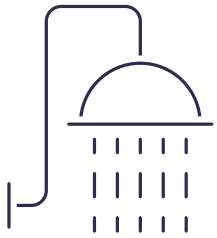
- The following people are trained and equipped to intervene **in the controlled zone in the VAA**: the personnel of the Mobile Emergency and Resuscitation Services (SMUR), the fire brigade personnel of the Fire and Rescue Services (FRS), including the Rapid Response Health Unit (RRHU) and the personnel of the Mobile Radiological Response Units (MRRU), and the Internal Security Forces (ISF).
- The following people are trained and equipped to intervene in the **exclusion zone:** the fire brigade personnel of the FRS's, particularly the MRRU personnel. In situations of life-threatening emergency, the SMUR and FRS RRHU personnel can also intervene in exclusion zones if they have appropriate Personal Protective Equipment (PPE).

The personnel of healthcare facilities taking in victims that have not yet been decontaminated (Extreme Urgency – EU – medicalised or self-presenting contaminated persons) must be protected by appropriate PPE to prevent the risk of contamination (Hospital Victim Assembly Area – HVAA, hospital decontamination unit, imaging, operating theatre, etc.).

SEE SHEETS 6 22 30

Medical-surgical urgencies take priority over the treatment of contamination and irradiation.

3 Treatment of contamination cases as rapidly as possible



The treatment of external and internal contaminations is most effective when applied as early as possible, as soon as the potential contaminating radionuclide(s) has/have been identified.

- **In the event of dispersion of radionuclides in the environment,** the victim is removed from the contaminated environment and placed in safety.
- **In the event of external contamination,** the treatment is based on undressing (emergency decontamination) and showering (full decontamination) with protection of the airways.

SEE SHEETS 7 + 24 to 26 + 34

- **In the event of internal contamination,** antidotes are administered.

SEE SHEETS 7 27 34 + 37 to 40 + radionuclides handbook

4 Treatment of an irradiated victim

Any exposure to a source of irradiation must be confirmed and characterised (total or partial irradiation of the body). The irradiation severity must be assessed as quickly as possible because it determines the appropriate medical pathway and treatment.

Questioning the victim is an urgent priority in this assessment which leads to the filling out of a radiological risk assessment sheet for each victim. The investigative elements (circumstances of the event, dosimetric survey) are to be looked for on the scene of the accident, otherwise they risk being lost definitively.

SEE SHEETS 5 7 11

IN PRACTICE

Action to take in the case of irradiated or contaminated lesions

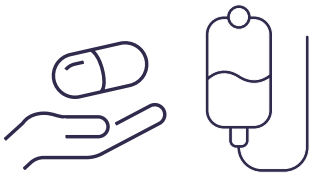
When acute irradiation and/or contamination are associated with traumatic lesions (fractures, injuries, wounds, burns), the prognosis of the lesions is aggravated: the injury potentiates the effects of the irradiation and *vice versa*. Whole-body irradiation increases the risk of cardiovascular shock, infection and haemorrhage, and slows down the healing of wounds and consolidation of fractures.

The first aid measures consist in controlling any severe bleeding (if necessary, take a blood sample for HLA tissue typing before transfusing), maintaining the circulatory function and freeing the airways to ensure satisfactory ventilation. After this, decontamination and/or internal contamination treatment must be started.

SEE SHEET 17

5 Provide appropriate treatment as quickly as possible

Once the victims are in a safe place, the appropriate treatments must be provided at each stage of the care process: symptomatic treatments, (assisting a vital function, complementary therapies, etc.), specific treatments (chelating agents).



IN PRACTICE

What are the action priorities in emergencies involving a large number of victims?

In situations with large numbers of victims, the civil security and urgent medical aid response is organised on the site of the event in order to treat as many victims as possible. The on-site response organisation is governed by Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 2011[1].
It is divided into three separate zones: **an exclusion zone, a controlled zone and a support zone.**

The victims must be prioritised by triage.

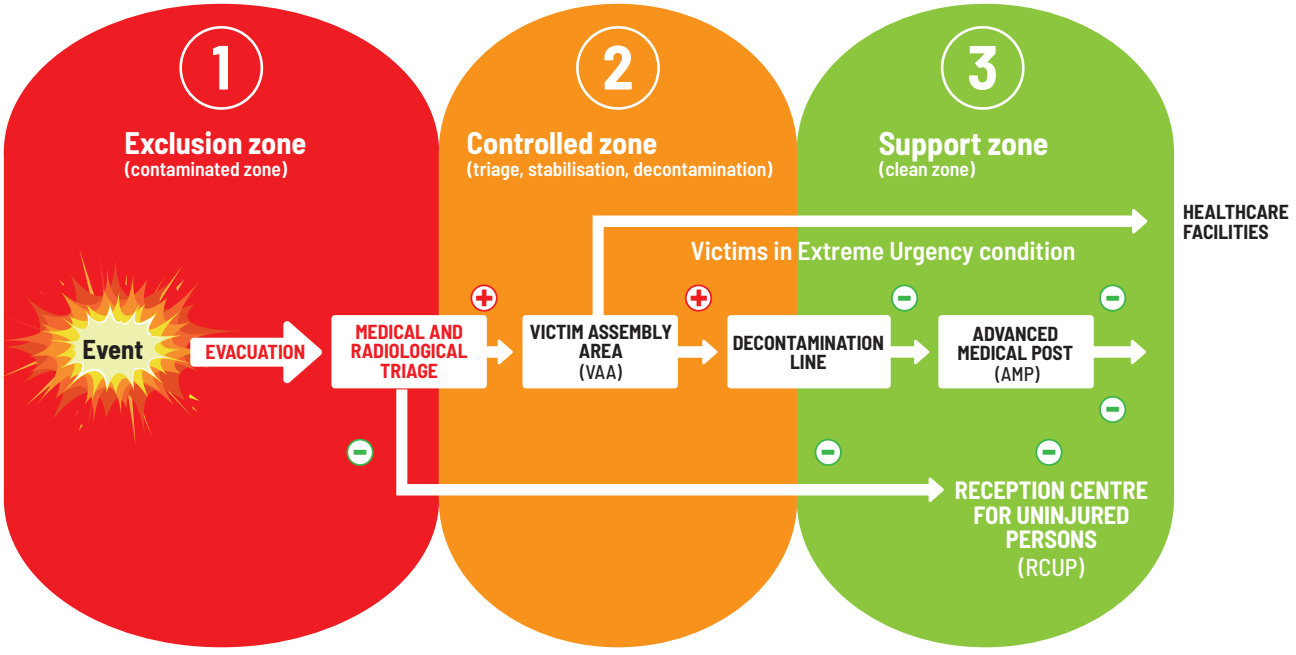
- **Front-end triage,** before going to the Victim Assembly Area for Chemical, Radiological and Nuclear risks (VAA CRN). If many people are involved, triage is vital in order to rapidly assess the condition of each victim and determine decontamination and initial treatment priorities.

An Advanced Medical Post (AMP) may be set up, depending on the severity, the number of victims and the scaling of the emergency response services.

- **Organisation of victim transfers:** the medical regulation by the Emergency Medical Assistance Service (SAMU) organises the transfers to the healthcare facilities capable of continuing the resuscitation strategy initiated in the field (1st line healthcare facilities, and notably the Regional Reference Hospital for the RN risk (RRH RN), or even the National Reference Hospital (NRH RN). Only the casualties identified as EU are evacuated to a 1st line healthcare facility without full decontamination, subject to the approval of the SAMU and the receiving facility.

SEE SHEET 18

DIAGRAM No. 1
→ **Victims' pathway** *(simplified diagram)*



⊖ Non-contaminated victims
⊕ Contaminated victims

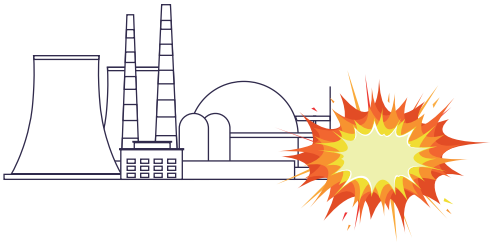
1. Circular relative to the national doctrine concerning the use of emergency and medical care resources in the event of a terrorist attack involving radioactive materials.

SHEET 04

MEDICAL RESPONSE STRATEGY

The 3 types of victim

In the event of a voluntary act or an accident of radiological or nuclear (RN) origin involving a risk of radioactive contamination and irradiation affecting a large number of victims, the emergency medical care organisation must be appropriate for the management of all the victims, distinguishing the following three types.



Casualties present on the site of the event

The injured persons are potentially contaminated and/or irradiated. Casualties can be divided into Absolute Urgencies (AU), which includes the Extreme Urgencies (EU), and Relative Urgencies (RU). This categorisation of the casualties is carried out on site by the medical teams of the Mobile Emergency and Resuscitation Service (SMUR) and/or the Rapid Response Health Unit (RRHU) of the Fire and Rescue Services (FRS). Another medical triage is carried out at the reception of 1st line healthcare facilities, particularly with self-presenting victims.

The management of these casualties complies with the usual response principles in disaster or accident situations involving a large number of victims: whatever the circumstances, medical-surgical urgencies take priority over the treatment of contamination and irradiation. The urgent medical actions must therefore be taken before carrying out any decontamination procedures.

The AUs must receive medical care and be evacuated rapidly. Among them, the EUs must receive medical or possibly surgical treatment without delay. They are likely to be evacuated directly after stabilisation without full decontamination, subject to agreement between the Emergency Operations Commander (EOC), the Medical Operational Coordinator (MOC) and the regulating physician of the Emergency Medical Assistance Service (SAMU), supported if necessary by the medical consultant of the Regional Reference Hospital for the RN risk (RRH RN).

The RUs undergo prehospital decontamination (emergency decontamination and full decontamination), before being evacuated to a healthcare facility.

A residual contamination check must be carried out using a detector equipped with a suitable probe. SEE SHEET 25

PAEDIATRIC VICTIMS

The principles applied to adults also apply to children.
If a child is unaccompanied or is incapacitated, provisions must be made to accompany them. If a child goes through the able-bodied persons' line, they must be accompanied by a relative or someone they know whenever possible.

Uninjured persons present on the site of the event

The uninjured persons are assembled in a Reception Centre for Uninjured Persons (RCUP).

Persons who have not undergone a contamination check[2] on the site of the event, shall be checked for contamination just before they enter the RCUP.

If necessary, decontamination will then be organised by the authorities.
This procedure starts with questioning of the victims, by which they can be classified in one of three categories (contaminated, irradiated, contaminated and irradiated).

The victims are then directed to the appropriate care structures according to their category.

The people situated near the site of the event

The people not present on the site of the event but situated nearby (permanent or occasional residents) are potentially concerned. They are also grouped in an RCUP.

These people may be effectively impacted by the event, feel potentially directly involved or worry that they might have been exposed or contaminated.

A medical examination and body contamination check are carried out at the RCUP.

An information and support unit associated with medical-psychological care provided by the Emergency Psycho-Medical Units (EPMU) may be put in place in order to identify people requiring medical follow-up.

NATURE OR TYPOLOGY OF VICTIMS ACCORDING TO THE TYPE OF ACCIDENT

The victim typology depends on the nature of the event or its modus operandi for terrorist attacks (*e.g.* use of explosives for the dispersion of RN agents resulting in complex casualties: injured, burned, blasted, contaminated irradiated).

These victims will require appropriate care in the pre-identified 1st line healthcare facilities and in the RRHH RN facilities which have specialised resources and skills.

The National Reference Hospital for the RN risk (NRH RN) is mobilised to treat the most serious victims in priority (examples: severe contaminations, paediatric care, etc.) and to provide their expertise to the other facilities.

SEE SHEETS 3 7

2. Hand-held radiological contamination meter. SEE SHEET 32

SHEET 05

MEDICAL RESPONSE STRATEGY

Questioning and description of the circumstances of an event

The anamnesis must be based on specific questionnaires presented in several stages: during the triage of the victims, at the Advanced Medical Post (AMP) or in the healthcare facility if irradiation is suspected, when the patient is taken into medical care by a physician or, if applicable, a nurse.

Early vomiting is a sign of severity in acute radiation syndrome. It is vital to determine whether vomiting has occurred.

Victim triage stage

The triage questionnaire is filled out for all conscious victims in order to rapidly identify the most exposed persons: persons who were closest to the event or are showing early signs of irradiation. The questionnaire is analysed locally following the indications of the referring physicians: nuclear physicians, radiologists, radiation oncologists, physicians with expertise in radiation protection.

If a victim is unconscious, the information is obtained from witnesses (people who were close to the victim).

Triage questionnaire

(fill out three columns: "yes" / "no" / "details" on the Word file)

Download the triage questionnaire Word file

1 • **Where were you at the time of the event?**
2 • **Roughly how far were you from the site of the event?**
3 • **Were you in a room?** Which room?
4 • **Were you outside a building?**
5 • **How long did you remain on the site of the event?**
6 • **Do you have any digestive problems** (nausea, vomiting, diarrhoea)?
7 • **At what time did you vomit?**
8 • **Do you feel very tired?**
9 • **Do you have a headache?**

IN PRACTICE

For all the questionnaires

Each questionnaire must be completed as quickly as possible. A sheet must be filled out for each victim giving a precise description of the circumstances of the event and all the necessary listed information.

The questionnaires indicate the victim's identification data (including the AMP patient number and the SINUS, SI-VIC tag), the name of the physician or nurse who administered the questionnaire and the date and time it was filled out.

If irradiation is suspected

The detailed questionnaire and the medical examination questionnaire supplement the triage questionnaire. They concern all victims identified as being exposed to a risk of irradiation.

Detailed questionnaire

The detailed questionnaire serves to evaluate the received dose if irradiation is suspected.

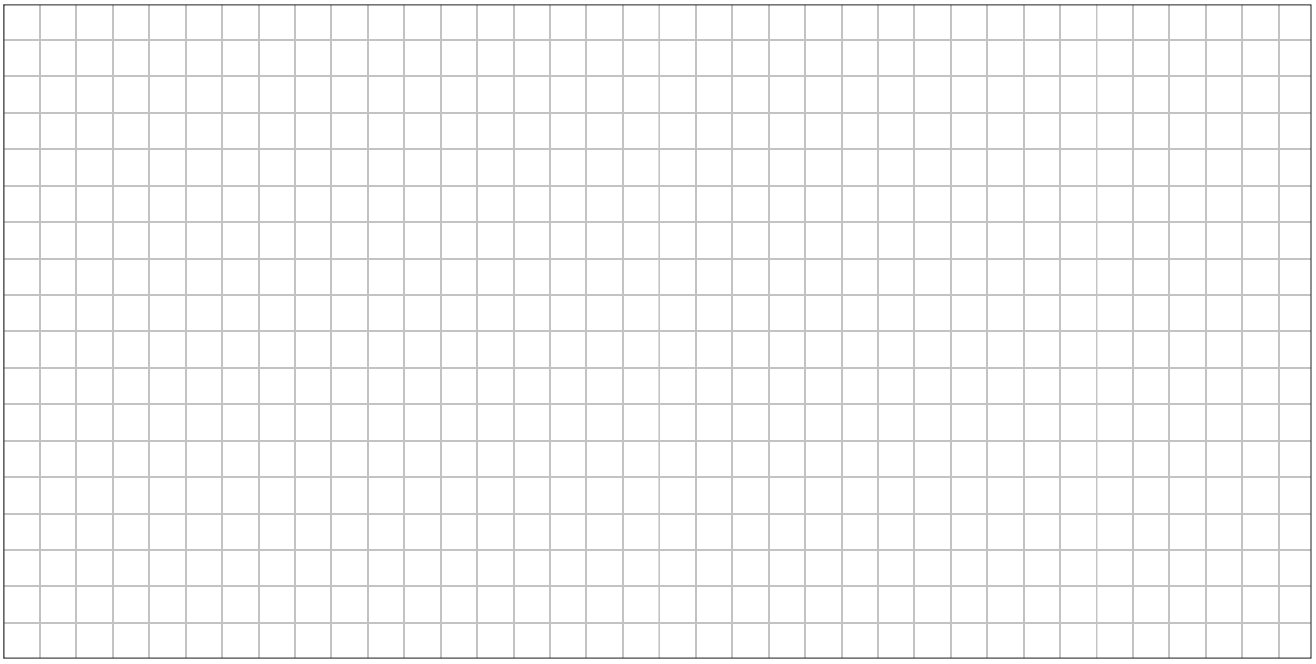
Download the detailed questionnaire Word file

Part 1: The circumstances of the accident

1 • **Were you in a building?** Which building?
2 • **Were other people present and close to you?** How many people? Who were they? (Names)
3 • **Can you estimate how far away from you they were? How long did they remain beside you? What were their respective positions?** Standing, sitting, lying down, other?
4 • Describe precisely what you were doing at the time of the accident. **What was the duration of each task you did following the accident?**
5 • **What route did you take to reach the assembly area? How long did you take to reach the assembly area?**
6 • Describe your near environment. **Distance and position with respect to the source and the shielding: were you close to structures situated between yourself and the site of the incident? Made of concrete? Another material? Can you indicate their size and approximate thickness?**
7 • **What position were you in?** Standing, sitting, lying down, other?
8 • **Do you have a telephone or any other electronic object on your person? Do you have a watch, spectacles, a packet of cigarettes, sweets, medication, sugar or sweeteners?** Indicate their location at the time of the accident (for example, in which pocket). These objects can be useful for the dosimetric reconstruction.
9 • For the workers: do you know the nature and activity of the radioactive source? The type of radiation, the dose, the dose rate? Were you wearing a dosimeter? Active or passive?

The questionnaire is supplemented by an accurate diagram: illustrate the places where the victim was situated at the time of the event, locate their position on the ground, in the area and with respect to the initial point of the event, and the position of any people present around the victim (markings on the ground).

To position the various elements as accurately as possible, while observing the proper distances, you can for example use the grid shown below (1 square = 0.50 metres x 0.50 metres).



Detailed questionnaire (cont'd)

Part 2: The reported disorders

10 • **Are you experiencing nausea?** Since when? Slight or severe?
11 • **Do you have abdominal pains?** Since when? Slight or severe?
12 • **Have you experienced loss of consciousness?** When? How many times?
13 • **Do you have difficulty swallowing?**
14 • **Have you experienced dizziness?** Since when? Slight or severe?
15 • **Have you vomited since the accident?** How many times? At what time?
16 • **Have you had diarrhoea since the accident?** How many times?
17 • **Do you feel tired? Exhausted?** Since when?
18 • **Do you have a headache?** Since when? Slight or severe?
19 • **Have you eaten since the accident?**

Part 3: The observed disorders

20 • **Does the subject display redness of the skin?** Since when? Indicate the exact location: face, hands, other.
21 • **Did the subject vomit during the questioning?** Note scrupulously: number of times, time and duration of vomiting.
22 • **Did the subject have diarrhoea during the questioning?** Note: number of times, time and visual aspect.
23 • **Does the subject seem to have difficulty in answering the questions?**

If the answer to even just one of the preceding questions is "yes", the following medical examination questionnaire must be filled out in the field (Advanced Medical Post – AMP).

Medical examination questionnaire

The medical examination questionnaire is filled out by the medical personnel in the AMP or the healthcare facility, in addition to the usual medical examination of any victim.

Download the medical examination questionnaire Word file

Does the subject present:

1 • **An erythema, a burn, a wound?** Since when? Indicate its exact location (diagram or photo).
2 • **Asthenia?** Since when? Moderate, severe?
3 • **Periods of nausea since the event?** Moderate, severe?
4 • **Abdominal pains?** Since when? Moderate, severe?
5 • **Vomiting?** Note the times.
6 • **Diarrhoea?** Since when? Moderate, severe? **How many stools since the accident? Liquid or solid appearance?** Note the times.
7 • **Difficulties in swallowing?** Appearance of the oro-pharyngeal mucosa: normal, inflamed?
8 • **Headaches?** Since when? Moderate, severe? Characterise them.
9 • **Dizzy spells?** Since when? Moderate, severe? Characterise them.
10 • **Loss of consciousness?** How many times? Characterise them.
11 • **Spatio-temporal disorientation?** Moderate, severe? Specify.
12 • **Ataxia?** Moderate, severe? Specify.

Medical management by a physician or nurse

Medical management questionnaire (preparation of the medical record)

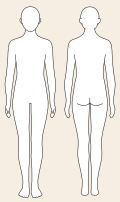
Download the medical management questionnaire Word file

Part 1: General medical management

1 • **Pathology and treatment:** Glasgow Coma Score – Dominant pathologies (Absolute Urgencies – AU / Relative Urgencies – RU): skull, thorax, abdomen, burned, poisoned, blast, fracture, polytraumatised, spine, other chemical, biological, radiological, nuclear (CBRN) risk? **Diagnosis and treatment** (peripheral venous catheter, intraosteal route, tourniquet, intubated). **Development**: improvement, stabilisation, aggravation (AU / RU / DECD)?
2 • **Transport and destination:** medicalised, non-medicalised, destination, service, means of transport, time, follower card (Victim Assembly Area – VAA / Advanced Medical Post – AMP / triage)?
3 • **Medical surveillance and development:** clinical, samples, therapeutic.

Part 2: Radiological management (radiological evaluation sheet)

Required information list:

4 • **Acute radiation:** yes/no, date and time, type of radiation (gamma/X-ray, neutrons), whole body and/or localised (part of body), estimated dose in gray (Gy) and diagram showing positioning with respect to the source.
5 • **Headaches and/or impaired consciousness:** yes/no, date and time.
6 • **Early erythema:** yes/no, location, date and time.
7 • **Nausea and/or vomiting and/or diarrhoea:** yes/no, date and time.
8 • **Hyperthermia:** yes/no, date and time.
9 • **Guidance:** total estimated dose (gamma/X-ray + neutrons) < 1 Gy (monitoring by) / total estimated dose (gamma/X-ray + neutrons) > 1 Gy Hospital
10 • **Associated chemical risk:** yes/no. Chemical agents concerned.
11 • **External contamination:** yes/no (if yes, indicate the contaminated zone).
12 • **Emergency decontamination:** yes/no, date and time.
13 • **Full decontamination performed:** yes/no, date and time.
14 • **Residual external contamination:** yes/no, detected or suspected radionuclides. *Diagram of the residual contamination* 
15 • **Internal contamination suspected:** yes/no.
16 • **Internal contamination:** measured by *in-vivo* radiation measurement (yes/non), radionuclides and activities measured, suspected (yes/no), radionuclides.
17 • **Contaminated wound:** yes/no, location.
18 • **Measurements – samples:** *in-vivo* radiation measurement – urine radiotoxicology – nostril sampling – skin appendage sampling indicating location (or time-stamped) – time-stamped blood samples: Complete Blood Count (CBC), platelets, reticulocytes / haemostasis biochemistry enzymology / sodium-24 / phenotyping of the erythrocytes (red blood cells) / HLA class I and II typing / chromosomal aberrations.
19 • **Internal contamination treatment:** Potassium iodide (yes/no, time). This treatment is administered as quickly as possible in cases of internal contamination by radioactive iodine – Radiogardase® (yes/no, time, dosage) – Ca-DTPA administered by slow IV injection or perfusion (yes/no, time, dosage) – Ca-DTPA by inhalation (yes/no, time) – DTPA on contaminated wound: one or more vials (yes/no, time).

SHEET 06

MEDICAL RESPONSE STRATEGY

Responders' equipment and means of protection

If there is any uncertainty about the nature of the event, the rule is that the first responders[3] must have maximum protection. It is only after any doubt has been removed, particularly regarding whether an associated chemical component is involved, that the protective garments can be adapted.

Emergency response and emergency medical aid teams

The teams must protect themselves to avoid being exposed to the radiological and nuclear (RN) risk, or to ensure that any such exposure is kept as low as possible. If there is any uncertainty about the nature of the event, the rule is to choose Personal Protective Equipment (PPE) that provides the first responders with maximum protection.

After dispelling any doubt and eliminating an associated chemical (C) risk, the PPE used can be adapted accordingly.

© ASN/P. Beuf

First-line PPE pending confirmation that there is only a radiological risk: garment permeable to air for the Chemical, Biological, Radiological, Nuclear (CBRN) risk and CBRN mask with filter cartridge

The professionals who are required to approach the closest to the site of the event wear appropriate garments for intervention in a hostile environment according to the zone in which they are situated and the nature of the risk (vapour, gas, dust).

- The SMUR personnel, the Fire Brigade (FB) personnel of the Fire and Rescue Services (FRS), including the Rapid Response Health Unit (RRHU) and the Mobile Radiological Response Units (MRRU) personnel, and the Internal Security Forces (ISF) are trained to intervene in controlled zones at the Victim Assembly Area (VAA). They are all equipped with PPE that is appropriate for chemical and radiological risks and masks with a broad spectrum cartridge providing P3 filtration effectiveness (ABEK 2 P3 NBC standard) which must be kept constantly operational by the healthcare facilities concerned (through the general interest mission funding delegated by the General Directorate for Health (DGS). The Regional Health Agencies check that the healthcare facilities keep the PPE operational.
- The FB personnel of the FRS, and the MRRU personnel in particular, are trained to intervene in exclusion zones[4]. They are equipped with appropriate protective garments that are permeable to air, in accordance with the equipment policy of each FRS. Respiratory protection is ensured by broad-spectrum CBRN cartridge filter masks with P3 filtration effectiveness. In situations of life-threatening emergency, the SMUR and the FRS RRHU personnel can also intervene in exclusion zones if they have appropriate PPE.

Second-line PPE once the chemical risk has been excluded

The means of protection are not bulky, are rapidly donned and do not unduly hamper the technical actions.

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Once the chemical risk has been excluded, the SMUR and FB personnel, including the RRHUs, can use PPE that is appropriate for the RN risk (non-woven coverall + FFP3 mask or, failing this, FFP2 + safety glasses + overboots + gloves).

SEE SHEET 22

3. National recommendations concerning protective clothing for RN risks (see INRS sheet "Personal Protective Equipment "ED 6077: https://www.inrs.fr/media.html?refINRS=ED%206077 and "Protective clothing", sheet, ED 995: https://www.inrs.fr/media.html?refINRS=ED%20995).
4. Within the meaning of the SGDSN guide of 8 March 2021 – *Good practices for deploying a Victim Assembly Area in the event of a chemical, biological, radiological or nuclear incident.*

Healthcare facility personnel

There are two possible cases:

CASE 1 **Medical management of a non-decontaminated victim** (self-presentation or Absolute Urgency – AU not decontaminated on the site of the event): the personnel dons appropriate PPE (non-woven coverall, + FFP3 mask or, failing this, FFP2 mask + active dosimeter).

CASE 2 **Medical management of victims decontaminated on the site of the event:** the personnel dons the usual work clothing. A check for residual contamination may be envisaged; this is the role of the Radiation Protection Expert (RPE).

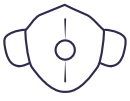
SEE SHEET 30

PROPER DRESSING PROCEDURE

Getting dressed properly means above all being able to get undressed properly and cleanly. Mastering the PPE dressing and undressing techniques is vital for the teams concerned. It is part of the initial and continuous training (at least once a year).

If the dressing/undressing procedure is not practised regularly, and given the inevitable stress in a radiological emergency situation, supervision by experienced personnel (supervisor) must be envisaged.

Equipment to use according to the level of contamination of the victims



Respiratory protection

- **Available deviceS:** from the complete mask with ABEK 2 P3 NBC cartridge to the disposable half-mask. The International Atomic Energy Agency (IAEA) recommends P3 filtration effectiveness for dust and aerosols.
- **Disposable FFP3 mask or, failing this, FFP2.**
- **Medical (surgical) masks:** these masks provide very limited protection.

Gloves: 2 pairs per person

- **Three selection criteria:** protection, dexterity, ergonomics.
- The gloves must be suited to the size of the hand and fingers and guarantee good sealing.
- **Double pair of gloves required:** change the outer pair of gloves if they get soiled.
- **RN risks:** favour nitrile or, failing this, latex surgical gloves (good protection and dexterity) with long cuffs.
- **Chemical risks:** if there is any doubt concerning an associated chemical agent, it is recommended to use butyl gloves with under gloves. Nitrile surgical gloves and latex gloves do not provide protection against certain substances, on the contrary.

Shoes: 3 possible solutions

- **Rubber boots.**
- **Butyl boots or overboots:** recommended if there are associated chemical risks.
- **Light protective overboots in non-woven material,** with non-slip soles.
  It is advised as a minimum to wear high-topped shoes or disposable clogs (for healthcare facilities), with protective overboots in all cases.

Other equipment

- **Safety goggles.**
- **Surgical caps,** if the coveralls do not have a hood.

Dosimetric monitoring of responders

The persons responding to a Radiological Emergency Situation (RES) take measures intended to prevent or reduce the risks associated with an RN situation.

They are tasked with protecting the populations or helping to maintain the functioning of an uninterruptible activity of strategic importance.

These tasks cannot be assigned to pregnant women, women who are breast-feeding, or young workers[5].

From the French labour law viewpoint, the RES responders are classified into two groups:

- The first group (group 1) comprises the workers whose effective dose could exceed 20 mSv during the radiological emergency. These workers are volunteers.
- The second group (group 2) comprises the workers whose effective dose could exceed 1 mSv but without exceeding 20 mSv (the SMUR personnel are classified in this group).

Group 1 responders receive special training while group 2 responders are suitably informed of the health risks and the precautions to take when intervening in a radiological emergency situation.

The French Labour Code obliges the use of dosimetric monitoring means that are appropriate for the radiological risk.

- The group 1 responder are equipped with a passive dosimeter and an active dosimeter appropriate for the situation. Rescuers working in the danger zone must have real-time dosimetric monitoring equipment.
- The group 2 responders are equipped with at least a passive dosimeter or, if the nature of the emergency situation does not permit this, their exposure is evaluated by any other appropriate method established by the employer with the support of the Institute of Radiation Protection and Nuclear Safety (IRSN). It may, for example, involve the use of an electronic dosimeter, collective dosimetry or an approach by calculation based on environmental measurements. The SMUR personnel have active dosimeters.

Dosimetric monitoring is ensured by the RPE in collaboration with the occupational physician.

- It concerns both external and internal exposure for the front-line responders (within the exclusion zone and the controlled zone[4]). For the second line (management of a potentially contaminated victim at the VAA, at the Advanced Medical Post (AMP) or in the healthcare facility), attention is focused on the monitoring or at least the evaluation of the internal exposure of the responders.
- The dosimetric information, or failing this the dosimetric evaluation, is determining for the occupational physician responsible for setting up the post-incident monitoring.
- At the end of the RES, the occupational physician prescribes all the examinations he/she considers appropriate for assessing the responders' state of health.
  The occupational physician establishes a dosimetric assessment for each worker which is recorded in the occupational health medical record.

Each worker having intervened in an RES is subject to the tightened monitoring measures applicable to workers classified in category A for at least five years following the RES, or during the period in which the received dose remains higher than one of the occupational exposure limits.

5. "Young workers" means workers aged from 16 to 18.

EXTERNAL DOSIMETERS FOR THE RESPONDERS

© Bertin Technologies

Active dosimeter (electronic)

This a device which alerts the user and optimises radiation protection. It provides a continuous display of the dose accrued since the start of the operation and has a visual or audio alarm system with an adjustable triggering threshold. It enables the responders to self-check their radiation protection in hostile environments. It is used in accordance with the instructions of the RPE, who may revise them according to how the situation evolves. The alarm thresholds can be harmonised so that all the responders have the same triggering thresholds.

© APVL ingénierie

Passive dosimeter

These dosimeters are assigned to named individuals and allow an integrated dosimetric measurement during the emergency period. The dosimeter analysis cycle usually takes several days (dispatch to laboratory, analysis, return), but can be expedited if necessary. IRSN holds a permanent stock of several hundred dosimeters which can be issued immediately at the request of the public authorities in the event of a crisis. Generally speaking, the dosimeters used and worn on the chest are suitable for the types of radiation likely to be encountered: X-rays, gamma and/or beta rays, neutrons. Extremity dosimeters and eye lens dosimeters can also be worn if necessary.

SEE SHEET 16

© Grégoire Maisonneuve/ Médiathèque IRSN

© Landauer

SHEET 07

MEDICAL RESPONSE STRATEGY

Decontamination and internal contamination treatment procedures

Medical-surgical urgencies take priority over the treatment of contamination and irradiation. In the event of a large-scale accident with numerous casualties, decontamination is carried out in two stages: first emergency decontamination, then full decontamination. Internal contamination is treated as early as possible.

Emergency decontamination

Emergency decontamination begins by protecting the upper airways (to prevent external contamination from leading to internal contamination) by putting an FFP3 mask or, failing this, an FFP2 mask on the victim after cleaning the face.

If the contamination takes the form of dust, spraying lightly with water prevents the dispersion of the dust deposited on clothing. **The skin must not be bare or be wet,** to avoid letting contamination of clothing lead to skin contamination. Particular attention must be paid to potentially contaminated run-offs.

Whenever possible, emergency decontamination continues with removal of the outer layers of clothing and putting on a surgical cap.

Full decontamination

Full decontamination follows on from and supplements emergency decontamination (showering in an appropriate mobile or fixed structure with collection of the effluents).

Its purpose is to remove all traces of residual contamination. The aim is to enable the victims to be treated without the responders having to take special protection measures and to prevent the transfer of contamination within the healthcare facility to the patients, the hospital personnel and the equipment.

A decontamination check is mandatory. If contamination persists, further decontamination is necessary.

After two full decontamination passes, the residual contamination is considered to be fixed. Consequently there is no longer any risk of transmission to the healthcare personnel.

The decontamination procedure by type of victim is detailed in the following table.

Internal contamination treatment

If possible, the treatment must be administered within two hours following contamination: as early as possible once the potential contaminating radionuclide(s) has/have been identified.

A radionuclide incorporated within an organism irradiates the tissues. The duration of irradiation varies depending on the half-life of the radionuclide and its biological retention in the organs.

The therapy aims to speed up the natural elimination of the contaminant. It reduces the quantity of radioactivity retained in the organism and hence the dose received by the tissues/organs and the risk of radiation-induced cancer.

Principal dose reduction mechanisms:

1. Increase the excretion of the radionuclide: increase by isotopic dilution (*e.g.* tritium diluted by water), mobilisation (e.g. strontium mobilised by stable calcium), blocking of storage (*e.g.* radioactive iodine) or chelation (*e.g.* with plutonium).
2. Reduce the gastrointestinal or pulmonary absorption (*e.g.* with caesium, indium or thallium with Prussian blue).

SEE SHEETS 27 + 38 to 40

DECONTAMINATION PROCEDURE BY TYPE OF VICTIM: MAIN REFERENCE POINTS

TYPE OF VICTIM		MEDICAL MANAGEMENT	DECONTAMINATION PROCEDURE
Injured victims present at the site of the event	**Absolute Urgencies (AU), including Extreme Urgencies (EU)**	Medical care and rapid transfer. EUs must receive medical and/or surgical treatment without delay. They are evacuated directly after stabilisation.	**For EUs:** no emergency decontamination. **For the other AUs:** emergency decontamination only. With certain stabilised AUs, a contamination check should allow full decontamination of any contaminated areas to be carried out after emergency decontamination.
	Relative Urgencies (RU)	Prehospital decontamination before transfer to a healthcare facility.	Emergency decontamination and full decontamination, followed by a residual contamination check.
Uninjured victims present at the site of the event *They are grouped in a Reception Centre for Uninjured Persons (RCUP).*		Internal and external contamination check in an RCUP (if this was not done on the site of the event). Questionnaire to classify the victims in one of 3 groups (irradiated, contaminated, irradiated and contaminated). Provision of medical-psychological support. The victims are directed to the appropriate care structures according to their category.	Full decontamination if necessary. Prophylactic treatment of internal contamination if applicable.
Population situated near the site of the event (permanent or occasional residents) *They are grouped in an RCUP.*		Contamination check in an RCUP. Questionnaire to classify the victims in one of 3 groups (irradiated, contaminated, irradiated and contaminated). Provision of medical-psychological support. The victims are directed to the appropriate care structures according to their category.	Full decontamination if necessary. Prophylactic treatment of internal contamination if applicable.

PAEDIATRIC VICTIMS

Decontamination procedure: The principles applied to adults also apply to children. If a child is unaccompanied or is incapacitated, provisions must be made to accompany them. If a child goes through the able-bodied persons' line, they must be accompanied by a family member or someone they know.

For the **treatment of internal contamination:** Particular attention must be paid to children (and, by extension, to pregnant and breast-feeding women) because they are the most radiosensitive population group.

SHEET 08

REGULATORY FRAMEWORK

Reference systems

These systems allow rapid and optimal medical care of patients on the site of the event and in the healthcare facilities, after medical regulation by the regionally competent Emergency Medical Assitance Service (SAMU).

In prehospital situation, for the rescue operations and emergency medical care

Management of the victims is based in particular on Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 2011 on the French national doctrine for the use of emergency rescue and medical care services in response to a terrorist attack involving radioactive materials.

The organisation is based on the following plans:

- the **"Orsec" (Organisation of the civil security response) plan,** activated by the Prefect (Off-Site Emergency Plan – PPI), Orsec NOVI plan[6]),
- the **regional application of the governmental "Chemical, Biological, Radiological, Nuclear" (CBRN) Orsec plan,**
- the **national response plan for major nuclear or radiological accidents**[7].

In the healthcare facilities

The medical care of victims of radiological or nuclear (RN) agents comes under the **Orsan plan**[8], and the **Orsan "Chemical, Radiological, Nuclear" (CRN) plan** in particular. The Orsan plan sets the framework for the organisation of the operational response of the healthcare system in exceptional public health situations and follows on from the Orsec plan as regards the medical management of victims in the health system.

If there are numerous victims of an RN agent, the **Orsan AMAVI plan** is activated jointly with the **Orsan CRN plan**. It governs the reception of large numbers of casualties to be managed simultaneously and follows in line with the **Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 2011 and the Orsec NOVI ("Numerous victims") plan.**

The medical management of victims suffering from psychological injuries is organised through the **Orsan MEDICO-PSY plan**.

THE ORSAN PLAN

The plan is developed in each region by the Regional Health Agency.

It organises the scaling up of the health system: coordinated mobilisation of the medical care operators (healthcare facility) and the health professionals.

It defines the medical care pathway of the victims and structures the care management routes.

It complements the Orsec plan for the management of victims in the health system (see diagram 4 on page 36).

THE ORSAN CRN PLAN

The plan organises, on the regional scale, the management in the health system of people exposed to an RN agent, in application of the Governmental CBRN Plan and the National Response Plan for Major Nuclear or Radiological Accidents.

The Orsan CRN Plan puts in place different medical management routes for the RN risk. It gives notification of the required capacities for the 1st line healthcare facilities, particularly the Regional Reference Hospitals (RRH): capacity for decontamination, radiotoxicological analyses, dosimetry, haematological intensive care unit, etc.

The plan provides for appropriate hospital decontamination measures to minimise the risk of contamination transfer within the healthcare facilities and to ensure the rapid treatment of the patients. It also provides for the reception and management of non-decontaminated EU cases.

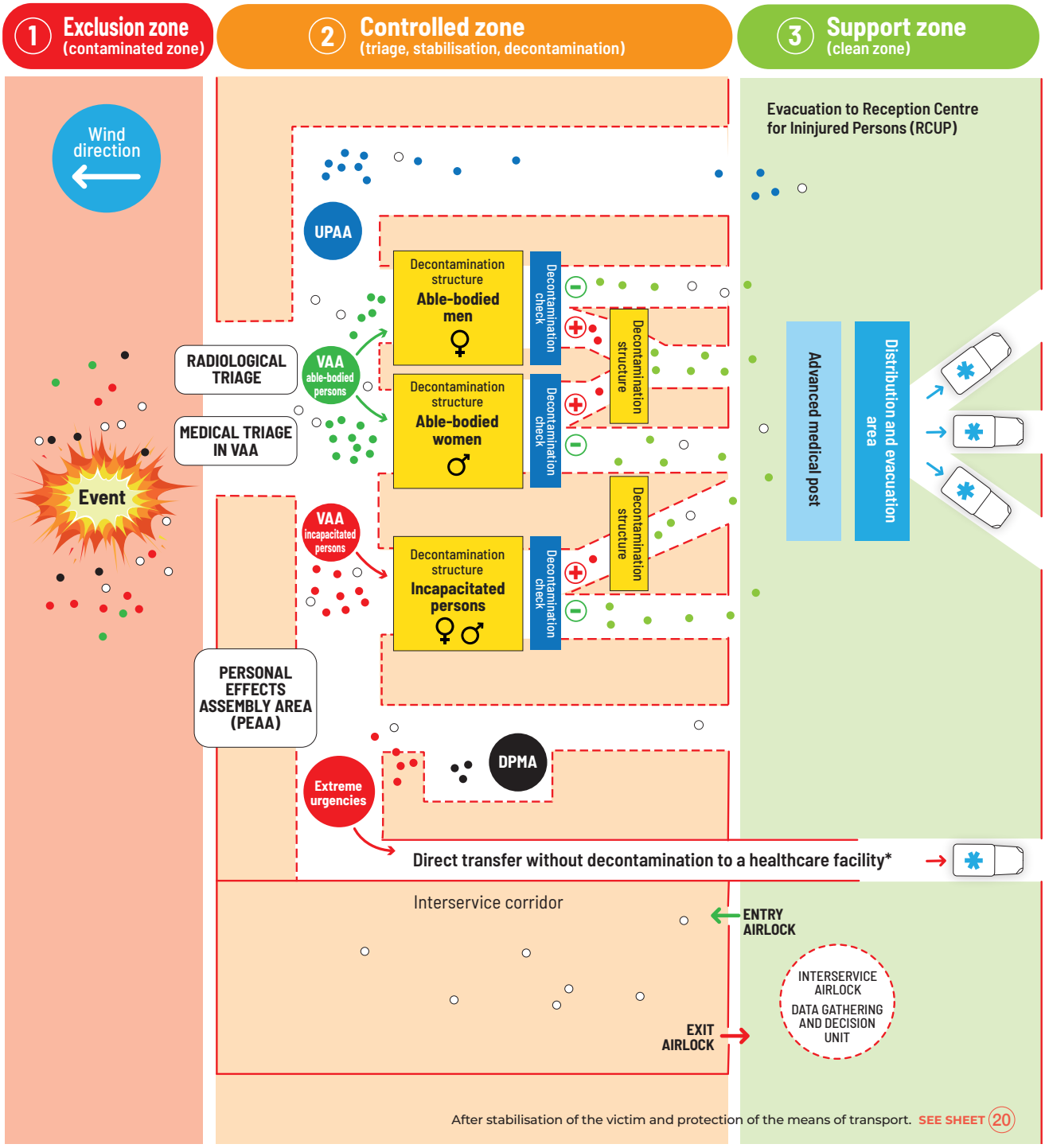
It follows on from the Orsec NOVI plan activated by the Prefect. It is complementary to the Orsan AMAVI plan and the Orsan MEDICO-PSY plan.

6. General Directorate for Civil Security and Emergency Management *(Direction générale de la sécurité civile et de la gestion des crises). Orsec departmental and zonal guide to "NOVI"* (Emergency response in situations with numerous victims) (Guide G6 – November 2014).
7. The specific provisions of the National Response Plan for Major Nuclear or Radiological Accidents are implemented if a nuclear event occurs. This plan serves to ensure the medical management of the exposed persons.
8. General Directorate for Health *(Direction Générale de la Santé). Orsan Guide – Organisation of the Healthcare System Response in Exceptional Public Health Situations* (2019).

DIAGRAM No. 2

General organisation of the response in a nuclear or radiological emergency

Diagram taken from Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 2011 on the French national doctrine for the use of emergency rescue and medical care services in response to a terrorist attack involving radioactive materials.



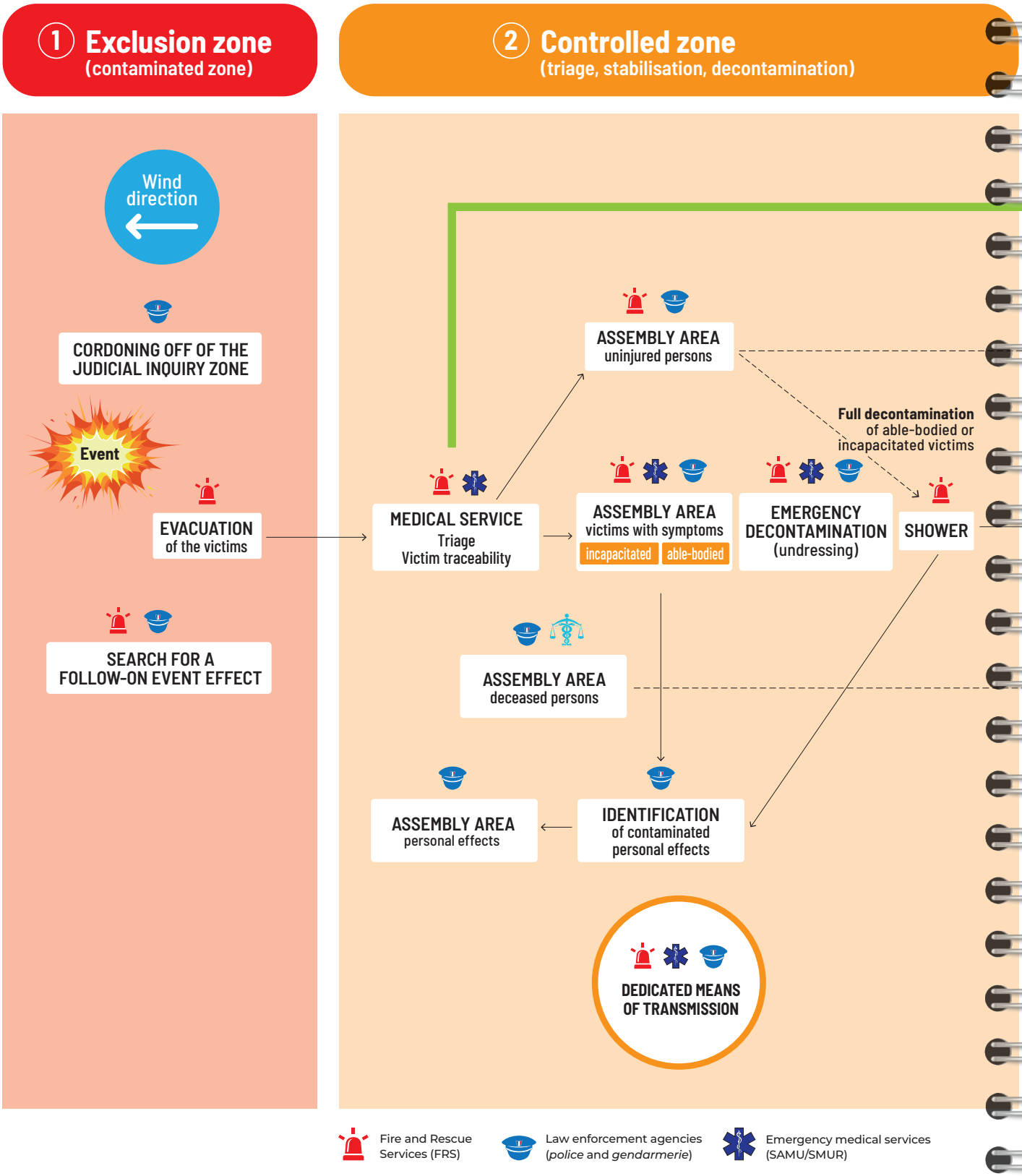
DPMA: Deceased Persons Management Area
PEAA: Personal Effects Assembly Area

UPAA: Uninjured Persons Assembly Area
VAA: Victim Assembly Area

- Uninjured victims without symptoms
- Able-bodied victims with symptoms
- Decontaminated victims
- Incapacitated victims with symptoms
- Deceased victims
- Medical team personnel

DIAGRAM No. 3

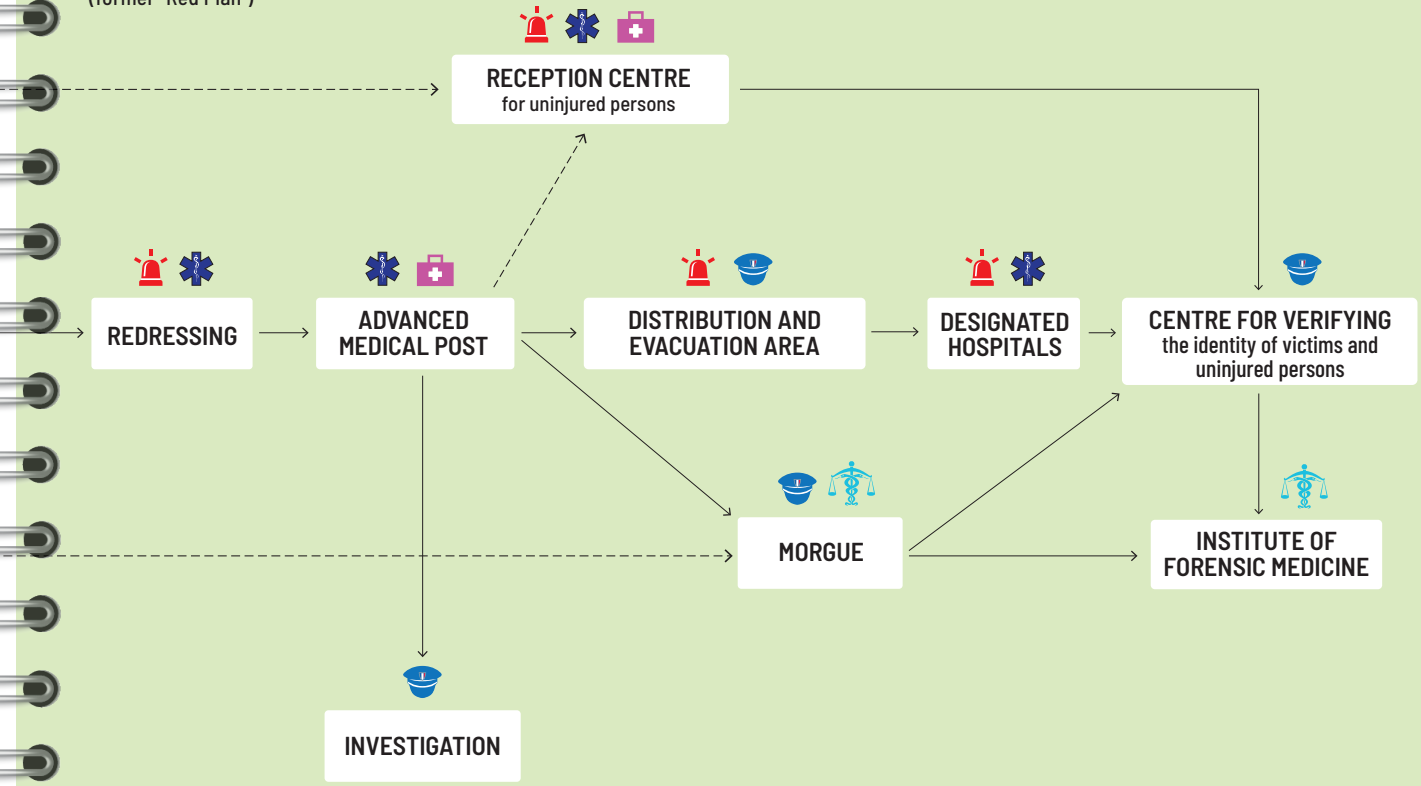
Organisation of the services and actions of the first responders in a nuclear or radiological emergency



3 Support zone
(clean zone)

Direct transfer of Extreme Urgency (EU) victims to a healthcare facility*

Departmental Orsec plan to provide relief when many victims are involved (former "Red Plan")



SITE COMMAND POST

* After stabilisation of the victim and protection of the means of transport. SEE SHEET 20

First-aid associations
Forensic medicine
Healthcare facility

SHEET 09

REGULATORY FRAMEWORK

Organisation of relief and medical care

When faced with a radiological or nuclear (RN) emergency involving a large number of victims, the intervention of the medical teams to take care of the victims if a four-phase process. Organisation of the relief and emergency medical aid is governed by Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 2011[9].

PHASE 1 Activation

This phase concerns the alerting, the mobilisation of the medical teams and first-aid responders and informing about the presence of an RN risk.

The Call Reception and Regulation Centre (CRRC) and the Alert Processing Centre (APC) receive and analyse the alert in order to identify the nature of the potential RN risk as quickly as possible. The Internal Security Forces (ISF) are always informed.

It is vital for the operational centres to exchange information continuously and to define a First Destination Area (FDFA) and a Resources Assembly Area (RAA).

WHO DECIDES ON THE EVACUATION OF THE EXTREME URGENCIES (EU)?

The decision is taken by the Emergency Operations Commander (EOC) and the Medical Operational Coordinator (MOC), along with the SAMU which is in charge of medical regulation and informing the receiving healthcare facility.

If there are children among the victims, specialised teams – who have been identified beforehand – must be mobilised rapidly. The medical management of children follows the same procedure as for adults. The principles of child medical management are covered by professional recommendations (https://www.sfmu.org/upload/consensus/gbp_GT_NRBC_PEDIA-LG-161120.pdf).

PHASE 2 Prehospital medical care

The prehospital medical response on site is supervised by the MOC, in collaboration with the regionally competent SAMU, which directs the patients to the appropriate healthcare facilities (medical regulation of transfers). The relief and emergency medical care are dispensed as required at the different stages of the victim management pathway.

The SAMU and the Fire and Rescue Services (FRS) must implement operational and regulation procedures that are appropriate for this type of event. These procedures identify the medical teams of the Mobile Emergency and Resuscitation Services (SMUR) and the Rapid Response Health Unit (RRHU), that can intervene in controlled zones.

- The medical teams provide the victims with medical care in the Victim Assembly Area (VAA) as soon as possible after their evacuation from the exclusion zone.
- Full decontamination of the victims (injured and uninjured persons) is carried out on leaving the VAA. This is the responsibility of the specialised FRS units[9]. The healthcare facilities must nevertheless be prepared for the arrival of unannounced, non-triaged and non-decontaminated victims who missed the prehospital screening. They are taken care of in the Hospital Victims Assembly Area (HVAA).
- In a mass casualty emergency situation, the principles of disaster medicine are applied. In this context, the aim is to deliver damage control care: the SAMU categorises and prioritises the injured persons according to the nature of their lesions in order to organise medical regulation.
- Dispatching victims to the 1st, 2nd or 3rd line healthcare facilities is the responsibility of the regionally competent SAMU. If necessary, dispatching is done with assistance of the zone SAMU and the Regional Reference Hospital for the RN risk (RRH RN).

9. Circular relative to the national doctrine concerning the use of emergency and medical care resources in the event of a terrorist attack involving radioactive materials.

MEDICAL MANAGEMENT BY TYPE OF VICTIM

Medical-surgical urgencies take priority over the treatment of contamination and irradiation. If child victims are involved, plan for them to be accompanied by a family member or a person they know whenever possible.

TYPE OF VICTIM		MEDICAL MANAGEMENT
Injured victims present on the site of the event *The urgent medical actions are taken before full decontamination*	**Absolute Urgencies (AU), including Extreme urgencies (EU)**	• Medical treatment and rapid transfer after stabilisation without full decontamination. • EUs must receive medical and/or surgical treatment without delay. They are transferred directly after stabilisation.
	Relative Urgencies (RU)	• Prehospital emergency and full decontamination, followed by residual contamination check before transfer to a healthcare facility.
Uninjured victims present at the site of the event	**Potentially contaminated**	• Assemblyrouping of the victims in a Reception Centre for Uninjured Persons (RCUP). • Internal and external contamination check in the RCUP if this was not done at the scene of the event. • Questionnaire to classify the victims in one of 3 groups (irradiated, contaminated, irradiated and contaminated). • Clinical examination, samples and further examinations if necessary. • Decontamination if necessary. • Psychological support from the Emergency Psycho-Medical Unit (EPMU), etc.
	Non-contaminated	• Assembly of the victims in an RCUP and psychological support from the EPMUs.
Population near the site of the event *Permanent or occasional residents*		• Medical management identical to that of the uninjured, potentially contaminated victims present on the site. • An information and support unit associated with medical-psychological support may be put in place in order to identify people requiring subsequent medical follow-up.

PHASE 3

Hospital care

This phase covers the hospital treatment and rehabilitation of the victims.

- The healthcare facilities are mobilised under the plan for managing hospital resource shortages and exceptional public health situations: "Chemical, Radiological, Nuclear" – CRN section and, if there is a massive influx of victims, the "Mass reception of non-contaminated victims" – AMAVI section, by activating level 2 of the "White plan".
- As soon as the alert is received, the healthcare facilities get prepared to receive the victims sent to them after regulation by the SAMU (EU). A Crisis Medical Director (CMD) organises the victims' intra-hospital care pathway in collaboration with the hospital crisis unit and the SAMU. They apply a strategy for protecting the personnel and the infrastructure.
- If self-presented victims arrive, hospital decontamination is carried out at the entrance of the healthcare facilities. It aims to ensure the protection of the personnel and the facility during the medical management of the victims. It is carried out in two stages:
  1. emergency decontamination at the HVAA;
  2. full decontamination in the Hospital Decontamination Unit (HDU).

SEE SHEETS 29 to 35

PHASE 4

Post-crisis

During this phase the health system gradually returns to normal functioning and the lessons learned from the event are established.

MOBILISING REINFORCEMENTS

The Regional Health Agency of the defence zone organises the inventorying of the human resources, health products (medicines, including radionuclide antidotes/ chelating agents and oxygen) and the equipment available in the region.

Reinforcements can be mobilised:

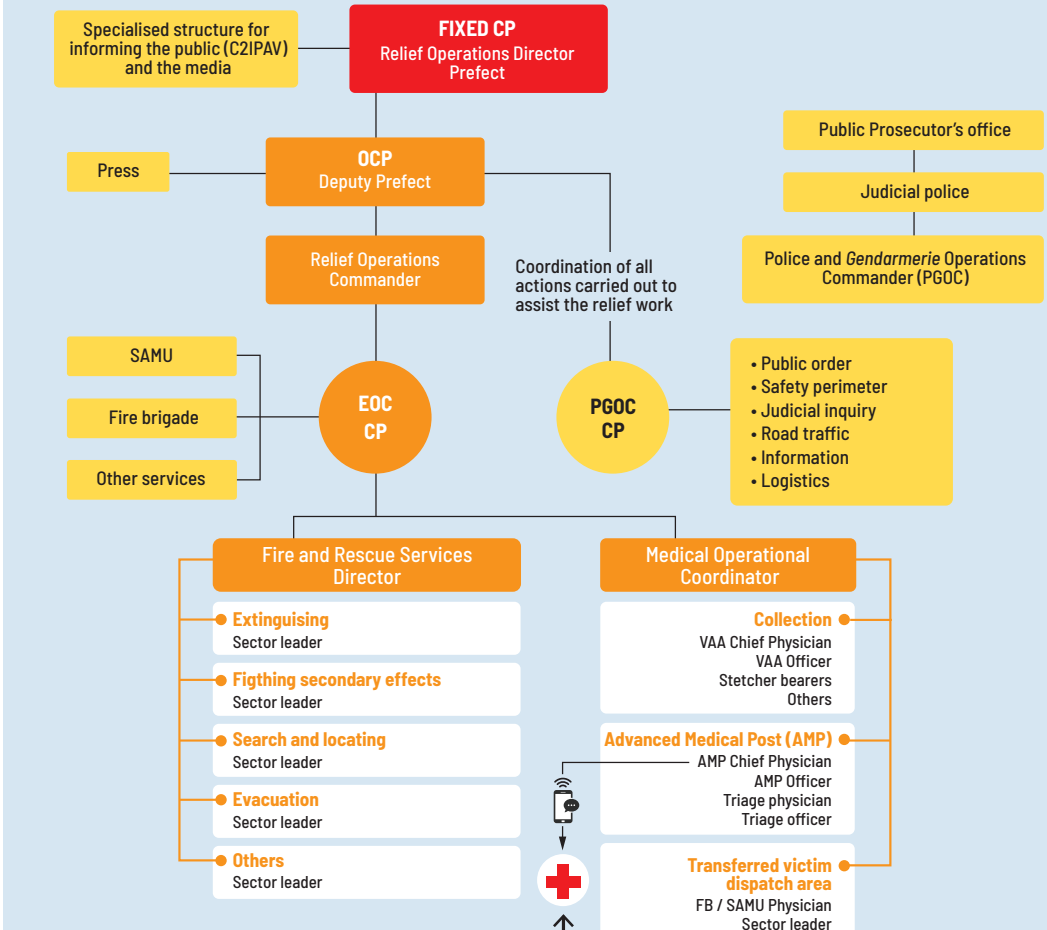
- **zonal reinforcements** of the defence zone by the Regional Health Agency at the request of the Regional Health Agency and activation of the Zonal Healthcare Resources Mobilisation Plan (PZMRS). The FRS reinforcements are coordinated by the Zone Operational Centre (COZ) of the defence zone affected by the crisis;
- **national reinforcements** by the Operational Centre for Regulating and Responding to Public Health and Social Emergencies – Health Crisis Centre (CORRUSS-CCS). The national means of the FRS are activated by the Interministerial Crisis Management Operational Centre. These reinforcements are mobilised under the national Orsan plan, possibly in collaboration with the Health Service of the Armed Forces.

SEE SHEET 19

DIAGRAM No. 4

Organisation of relief and medical care

Orsec plan
Prehospital care*



* Diagram taken from Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 2011 on the French national doctrine for the use of emer-gency rescue and medical care services in response to a terrorist attack involving radioactive materials.

Orsan plan
Hospital care**

Regionally competent
EMERGENCY MEDICAL SERVICE (SAMU)
Medical regulation of patients to healthcare facilities identified beforehand in the Orsan CRN plan (1st line healthcare facilities)

↕

REGIONAL HEALTH AGENCY
Regional unit supporting health management
Management of the Orsan "Chemical, Radiological and Nuclear " plan (Orsan CRN)

↕

1ST LINE HEALTHCARE FACILITIES
Plan for managing hospital resource shortages and exceptional public health situations *"White plan, CRN section"*
1. Regional Reference Hospital for the RN risk (RRH RN)
2. Other 1st line healthcare facilities

** Diagram taken from Instruction DGS/DUS/SGMAS No. 2014-153 of 15 May 2014 on the Preparation of the Healthcare System for the Management of Exceptional Public Health Situations and the guide *Organisation of the Healthcare System Response in an Exceptional Public Health Situation.*

EOS: Emergency Operations Commander
C2IPAV: interministerial unit for informing the public and providing aid to victims "public info"
CRN: Chemical, Radiological, Nuclear|
CP: Command Post
OCP: Operational Command Post
FB: Fire Brigade

SHEET 10

REGULATORY FRAMEWORK

Arrangements specific to healthcare facilities

The respective missions of the healthcare facilities defined in the Orsan plan set the framework of their action to provide medical care for the victims and to decontaminate them if this has not been done beforehand.

All the healthcare facilities must ensure a minimum level of personnel protection and emergency decontamination in the event of self-presentation of potentially contaminated persons.

Prehospital decontamination of victims in the field is the responsibility of specialised units of the emergency services

The injured or uninjured persons are decontaminated on the site of the event or in the immediate vicinity by the specialised units of the emergency services. This procedure complies with the circulars on the national doctrine concerning the use of emergency and medical care resources in the event of a terrorist attack involving radioactive materials.

Interministerial circular No. 800/SGDSN/PSE/PPS of 18 February 2011[10] provides for the possibility of evacuating a non-decontaminated absolute urgency (AU) to a Regional Reference Hospital for the Radiological and Nuclear Risk (RRH RN), subject to agreement between the Medical Operational Coordinator (MOC) and the medical consultant of the RRH RN.

It is nevertheless possible for victims to miss the prehospital screening

Some victims may self-present at the nearest healthcare facility or the one they usually go to for treatment. Most of these victims are able-bodied, but some may be incapacitated and brought in by third parties.

There is a potential risk of transferring contamination to the healthcare facility and its personnel. Appropriate protection and victim hospital decontamination measures must be taken (see ⓘ *"Implementation principles"* on the next page).

Hospital decontamination measures apply to the healthcare facilities

- **All healthcare facilities must be suitably prepared for the medical management of potentially contaminated self-presenting persons who have been exposed to a radiological risk.**
- The victims who flee the site of a radiological or nuclear (RN) event present themselves unassisted or are brought in by third parties. In principle these people are not AU cases, but **they are potentially contaminated by an RN agent and an aggravation of their condition is always possible.**
- **The hospital decontamination of these victims aims to allow their medical management in complete safety, by protecting the personnel and infrastructure of the facility against contamination.** Each healthcare facility must have considered this possibility and prepared a "Chemical, Radiological, Nuclear" (CRN) section in its Plan for managing hospital resource shortages and exceptional public health situations ("White plan, RN section").
- **The hospital decontamination measures differ** between the 1st, 2nd and 3rd line healthcare facilities (see ⓘ *"The three healthcare facility categories"* on page 39).
- **The management of decontamination operations applies not only to the 1st line facilities likely to receive non-decontaminated patients (EUs),** but also to all healthcare facilities having received contaminated victims. It is quite similar to the usual servicing and cleaning operations, but features several particularities. Rehabilitation of the premises must be declared after the absence of residual contamination has been confirmed by a competent entity. SEE SHEET 29

10. Circular on the national doctrine concerning the use of emergency and medical care resources in response to a terrorist attack involving radioactive materials.

Minimum protection measures and emergency decontamination

The measures indicated below follow the CRN section of the Plan for managing hospital resource shortages and exceptional public health situations, which provides for activation of the "White plan" and the RN medical care procedure: Hospital Victim Assembly Area (HVAA), Hospital Decontamination Unit (HDU), patient care sectors.

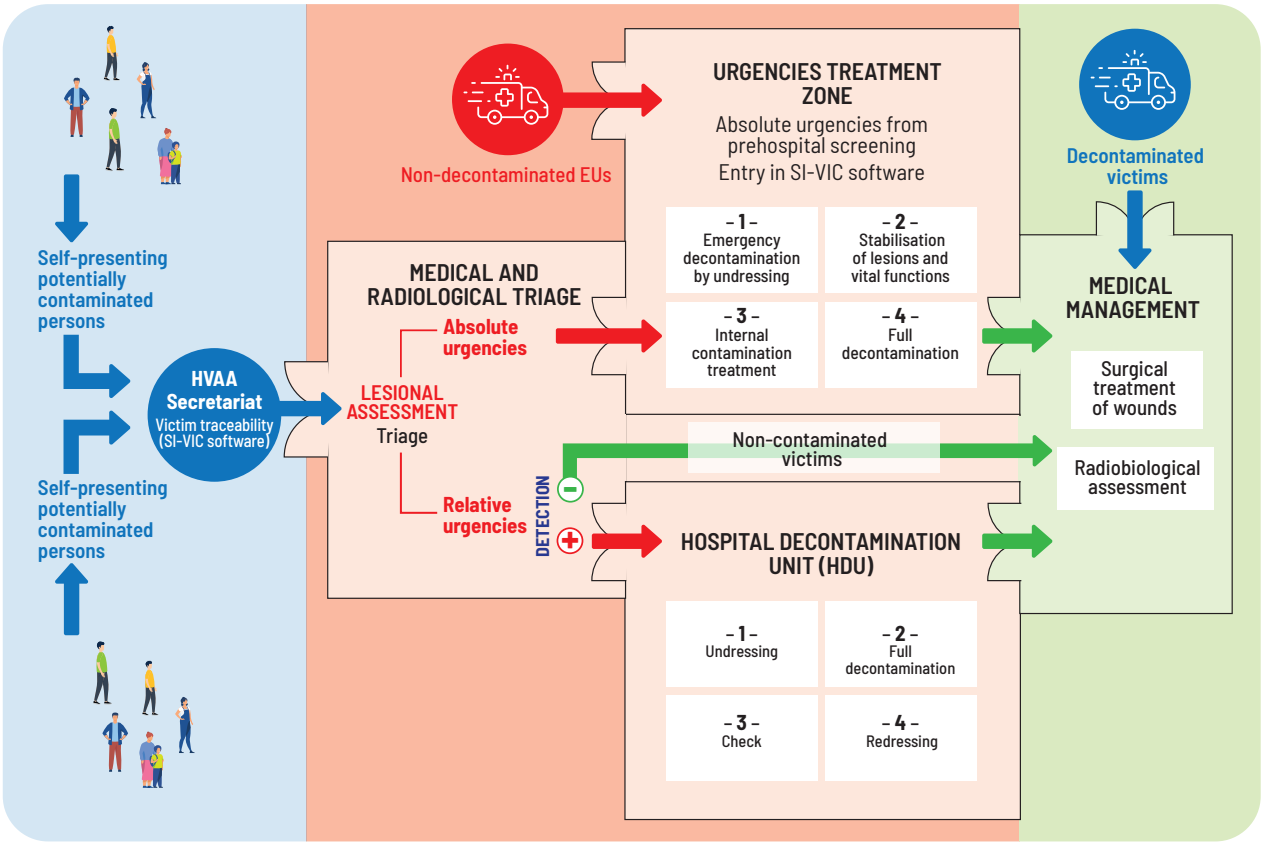
- **Detect** an unusual RN **event through the questionnaire.**
- **Alert *via* predetermined channels** the Director and the entities tasked with the security of the facility, the regionally competent Emergency Medical Service (SAMU) and the Regional Health Agency.
- **Protect its infrastructure, personnel, patients and visitors** (closing and securing of access points, doors and windows, protection of potentially exposed personnel, signposting of the victim reception channels and assembly areas).
- **Direct the persons who self-present at the facility** to a predefined zone and enable them to undress themselves under the supervision of trained personnel and place their clothing in a sealed plastic bag (emergency decontamination).

IMPLEMENTATION PRINCIPLES

1. The measures must be in conformity with the role of the healthcare facility planned for in the Orsan plan, and its CRN plan in particular.
2. The measures must be scaled according to the capacities of the facility, its proximity to the identified risks or sensitive sites, and the health area it serves.
3. The facility must be capable of activating the monitoring of its access points (facility security plan) without delay and of implementing its decontamination means or line very rapidly.

DIAGRAM No. 5

Ideal model of a reception setup in a 1st line healthcare facility *(general diagram)*



HVAA: Hospital Victim Assembly Area

Model of medical management in a healthcare facility

The healthcare facility must provide for:

- **Undressing of the patients.** Undressing removes 90% of the contamination. The patients are then directed to a full decontamination structure.
- **An external zone or a well ventilated room and a marked out route** to establish a circuit between the entrance and a waiting zone.
- **The personal protective equipment for the hospital personnel** who will be managing the patient.
- **"Contaminated victim" kits** and posters explaining the procedure for the emergency contamination of uninjured victims. The hospital personnel give each victim a kit, guide them through the procedure and put identification on the personal effects bags.
- **Management of the waste and rehabilitation of the premises.** SEE SHEET 29

Radioactive waste management

The arrival and treatment of potentially contaminated victims and management of the contaminations produce radioactive waste whose volume depends on the nature and scale of the accident. The waste can be liquid (washing water, etc.) or solid: vinyl covers, clothing, used Personal Protective Equipment (PPE), decontamination products, etc.

The key aspect of waste management lies in its radiological characterisation (nature of the radionuclides present) to determine whether on-site management of radioactive decay is possible or not.

In normal situations, the current regulations[11] allow on-site management of radioactive decay of waste and effluents containing radionuclides with a physical half-life of less than 100 days. Under these conditions, the aqueous effluents can be discharged into the environment provided that the activity concentration is less than 10 Bq/l and less than 100 Bq/l for effluents contaminated with iodine.

The solid waste can be disposed of by conventional routes when the contact dose rate is less than two times the background radiation.

If possible, the waste must be collected in containers that comply with the TMD-ADR[12] regulations for class 7, supplied by Andra, the French national radioactive waste management agency. It shall then be stored on site in the radioactive waste room in conformity with the regulations, if the facility has one (waste storage bunker of the nuclear medicine department, for example).

In a radiological emergency, the public authorities, together with the Prefect and the Regional Health Agency, are responsible for indicating what is to become of the waste and possibly collecting it on a storage site created for the circumstance or its transfer to an existing disposal facility.

SEE SHEET 29

THE THREE HEALTHCARE FACILITY CATEGORIES

The healthcare facilities are classified by the Regional Health Agencies for the Orsan plan and their Orsan CRN plan. The classification is determined according to the technical platform, the presence or not of an Accident & Emergency department, a SAMU, and the proximity of the facility to risks, sensitive sites or identified threats

1st line, including the RRHH RN

The 1st line facilities are capable of taking in and treating absolute urgencies (AUs) and relative urgencies (RUs) involving RN agents.

They have an authorised Accident & Emergency department, a medical-surgical technical platform, and a continuous care and/or resuscitation capability.

The context of their action (decontamination of victims) is set by the management plan for exceptional public health situations ("White plan", CRN section). They include: the healthcare facilities close to industrial sites, sites transporting hazardous materials and other sites presenting specific risks, the reference healthcare facilities and a few other specialised facilities. They are capable of treating irradiated and/or contaminated patients.

2nd line

The 2nd line facilities have a technical platform and can be mobilised for second-line treatment. They help to increase the capacity of the 1st line facilities. They might have to provide care to patients requiring medical treatments after full decontamination (resuscitation, etc.).

3rd line

The 3rd line facilities can be mobilised as a complement to the 1st and 2nd line healthcare facilities. They must ensure the minimum response when potentially contaminated persons self-present at the facility.

SEE SHEET 36

11. ASN resolution 2008-DC-0095 of 29th January 2008.
12. International regulation on the transport of dangerous goods coming under class 7 (radioactive materials) by road.

SHEET 11

BACKGROUND

Irradiation: definitions

External irradiation

The term external irradiation is used when the source of radiation is located outside the organism. Such exposure can be caused, for example, by a radioactive source which has been thrown away or lost, or by exposure to an industrial irradiator. The irradiation is most often acute, sometimes chronic.

- **A high total level of exposure of the whole body can cause Acute Radiation Syndrome (ARS).**
- **Partial exposure involving just one part of the body can cause a localised acute radiation syndrome.**

Action priority

The priority is to confirm the irradiation, to characterise it (total or partial irradiation of the body) and to evaluate its severity as rapidly as possible in order to determine the medical guidance and treatment of the victims.

- Questioning the victims is an urgent priority and serves to fill out of a radiological assessment sheet for each victim.
- The investigative elements (circumstances of the event, dosimetric survey) are to be looked for on the actual site of the accident, otherwise they risk being lost definitively.

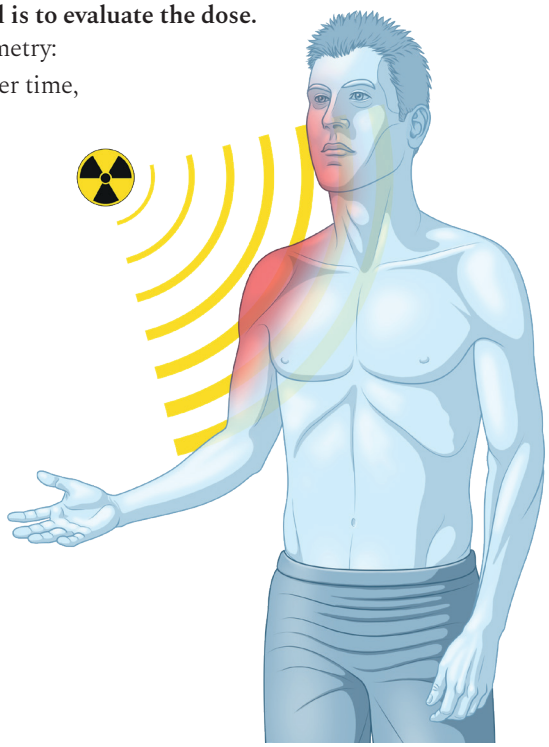
SEE SHEET 5

If there are associated medical-surgical issues to address: **the conventional emergency takes priority.**

From the radiological aspect, the urgent need is to evaluate the dose.
This evaluation is based on three types of dosimetry:

- clinical: clinical signs and how they evolve over time,
- biological,
- physical dosimetry.

SEE SHEET 12



Acute radiation syndrome (ARS)

A high total level of exposure of the whole body can cause ARS.
ARS appears further to whole-body irradiation at a high dose. It is clinically undetectable below 1 Gy.

Its severity depends on the level of the dose received and its distribution in the body; some target systems of the organism are particularly radiosensitive, notably the hematopoietic system.

The clinical development comprises four phases. The higher the dose received, the shorter and more intense each of the first three phases will be.

The four phases

1. **Prodromal phase or initial phase (initial syndrome):**
   it lasts from a few hours to 48 hours at the most.
2. **Latent period, clinically inapparent:**
   its duration varies from 7 to 21 days; it is absent in cases of very high irradiation levels.
3. **Critical phase or manifest phase:**
   phase during which the clinical consequences of the tissular damage manifest themselves.
4. **Recovery phase:** at sub-lethal doses, recovery can take several months.

Clinical signs

The symptomology of radiation sickness is not specific and can be similar to a case of trauma or poisoning.

ARS reflects the damage to various tissues: bone marrow, digestive system, respiratory system and the central nervous system. The higher the dose received and the larger the area of the body concerned, the earlier the clinical signs will appear.

Five broad groups of victims are described below, in decreasing order of severity.

Victims in groups I and II have a poor prognosis as there is no effective treatment at present.

CLINICAL SIGNS BY GROUP OF VICTIMS		
Groupe I	· State of shock · Cardiovascular collapse · Loss of consciousness	**Doses >25 Gy**
Groupe II	· Painful oedema of the parotid glands · Neurological signs (disorientation, convulsions, mental clouding) · Neurovegetative and vasomotor signs (hyperthermia, vigilance disorders, tachycardia and cardiac rhythm disorders) · Asthenia, anorexia	**Doses >12 Gy**
Groupe III	· Nausea, vomiting, diarrhoea · Headaches, pains in the parotid glands, dry mouth, drowsiness · Variable hyperthermia · Asthenia, anorexia	**Doses of between 2 and 12 Gy**
Groupe IV	· Nausea, vomiting, drowsiness, headaches, dry mouth · Asthenia (difficult to objectivise) · Anorexia	**Doses of between 1 and 2 Gy**
Groupe V	· The absence of early clinical signs does not exclude the possibility of irradiation at less than 1 Gy. · Hospitalisation is not indispensable, but a biological assessment must be proposed in order to confirm whether or not irradiation has occurred. SEE SHEET 12	**Doses <1 Gy**

Acute localised radiation syndrome

Acute localised radiation syndrome, or radiological burn, results from exposure of a part of the body to a not-too-distant source of radiation (chiefly X-rays, gamma rays and neutrons) or the deposition of radioactive particles on the skin (chiefly beta emitters).

Clinical presentation

INITIAL PHASE

The initial symptomatology only exists for very high doses to the skin.
Intense and early onset of these symptoms is always a sign of severity:

- initial sensation of heat;
- dysesthesia ("pins and needles" sensation) and immediate pains;
- erythema, early oedema.

LATENT PERIOD

Depending on the case, **the initial phase is followed by a latent period whose duration is inversely proportional to the severity of the irradiation.**

MANIFEST PHASE

The following will appear successively depending on the dose to the skin:

- cutaneous erythema (4 to 5 Gy),
- dry dermatitis, loss of hair (5 to 12 Gy),
- exudative dermatitis, blister (12 to 20 Gy),
- necrosis (>25 Gy).

The dosed indicated must be considered as rough estimates.

DEVELOPMENT

This syndrome is characterised by a dynamic development that is difficult to predict, as much in the kinetics of the extension or regression of the symptoms as in its extent in surface area and depth (surgical treatment is difficult).

Inflammation flare-ups and resurgence of necrosis are sometimes observed several years after the accident.

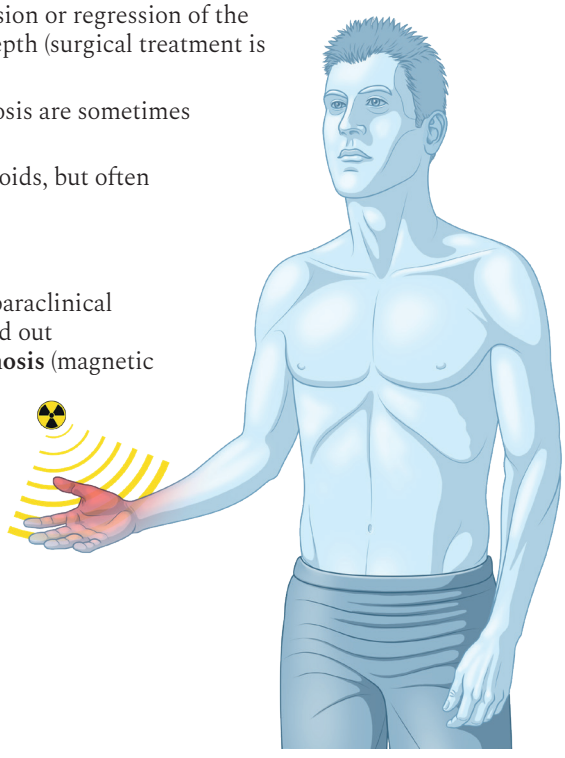
The pain is intense, permanent, resistant to opioids, but often sensitive to non-steroidal anti-inflammatories.

EXAMINATIONS

The symptoms settle in gradually over time. If paraclinical examinations are indicated, they must be carried out as from the initial phase to allow an **early diagnosis** (magnetic resonance imaging – MRI and ultrasound scan).

The recommendations of the experts of the Institute of Radiation Protection and Nuclear Safety (IRSN) and of the radiopathology experts enable the prescription of these examinations to be adjusted according to the lesional appearance and the dosimetric evaluation, which must be carried out concomitantly.

SEE SHEET 12



SHEET 12

BACKGROUND

Dosimetry: individual measurements and methods of evaluating the received dose

Determining the received dose on the basis of the clinical examination and/or the methods presented in this sheet is essential for evaluating the consequences of cases of exposure to ionising radiation and for determining the action to take with respect to the exposed persons.

Irradiation

Reading dosimeters

In the event of an irradiation accident involving a person who is habitually monitored for the risk of exposure to ionising radiation, **the received dose can be rapidly evaluated by reading the dose displayed on the active dosimeter or by sending the passive personal dosimeter by urgent delivery to the dosimetry agency for immediate reading.**

Biological dosimetry

Biological dosimetry is indicated for persons who might have received doses exceeding 0.1 Gy. **The analyses must be carried out as soon as possible.** Two analyses are essential: the Complete Blood Count (CBC) and the search for chromosomal aberrations. People likely to have received the highest level of radiation (proximity to the site of the event and clinical signs) are analysed in priority.

COMPLETE BLOOD COUNT

Lymphocytes figure among the most radiosensitive cells **With a subject suspected of having received a significant level of radiation, performing a blood count as early as possible is therefore very important.**

The downward trend in the number of lymphocytes is directly proportional to the received dose: the level of irradiation is determined according to the dosage carried out as early as possible after the accident, then again at 24 hours and 48 hours

SEE SHEET 15

SEARCH FOR CHROMOSOMAL ABERRATIONS

The search for chromosomal aberrations is the most sensitive biological dosimetry examination and **the most specific for irradiation.** It provides an accurate retrospective estimate of the received dose as from 0.1 Gy.

- Taking a sample in the first hours enables a rapid estimate of the dose to be obtained when necessary, particularly if there is any doubt about the interpretation of the CBC. It takes a minimum of 72 hours to obtain the result.
- In the other cases, the sample can be taken later, because there is no technical urgency for performing this analysis: The reliability of the examination remains the same whether the sampling is done on the same day or several weeks after exposure.

SEE SHEET 15

OTHER EXAMINATIONS

The prescribing of other examinations must be discussed according to the type and severity of the accident, seeking the expertise of the Institute of Radiation Protection and Nuclear Safety (IRSN) if necessary.

Possible examinations: HLA I and II typing, phenotyping of the red blood cells, measurement of amylase level, level of follicle stimulating hormone (FSH) in plasma, measurement of phosphorous-32 in the skin appendages or sodium-24 by whole-body radiation measurement or in the blood.

The characteristics and indications are described in SHEET 15

Numerical dosimetric reconstruction

The dose due to the external exposure received by the victim of a radiological accident can be evaluated by calculation. **This dosimetric reconstruction is carried out using the physical parameters of the accident,** seeking the expertise of IRSN if necessary:

- based on the information on the irradiation source: radionuclide and activity in the case of sealed sources, characteristics of the irradiator (collimator, etc.), parameters of the X-ray tube or accelerator, etc.
- based on the circumstances of the accident.

The questioning must be carried out within the shortest possible timeframe. A questionnaire sheet and an examination sheet must be filled out for each victim, giving a precise description of the circumstances of the accident. The following shall be indicated as a minimum:

- the type of radiation, the activity of the sealed source or the dose rate, the parameters of the X-ray tube, etc.;
- the distance between the victim and the source;
- the position of the victim with respect to the source and any shielding;
- the nature (material) and dimensions of the shielding, if any;
- the different exposure sequences;
- the exposure durations for each sequence.

SEE SHEETS 5 14

Retrospective dosimetry

MATERIALS

To confirm the exposure scenario and allow an estimation of the exposure of the different organs or tissues, **numerous materials present in the victim's personal effects or clothing can be used:**

- materials that might have been collected from the victims (fingernails, dental enamel, etc.);
- objects carried by the victims or present in their near environment during the accident (sugars, plastics, etc.).

TECHNIQUES

The techniques are based on Electron Paramagnetic Resonance (EPR) spectroscopy and Thermally or Optically Stimulated Luminescence (TSL and OSL respectively). The doses are associated with the information on the location of the samples taken.

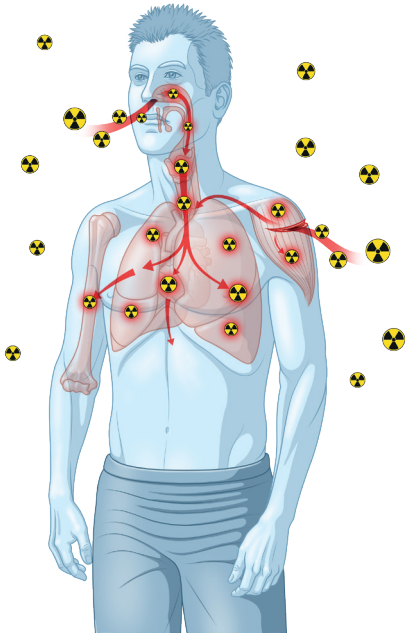
IN PRACTICE

IRSN, the advisor point of contact

IRSN has a dosimetry department, specialised in the reconstruction of doses in irradiation accidents and in retrospective dosimetry.

It also has a radiobiology laboratory for accidental exposures which carries out the quantification of chromosomal aberrations and provides its expertise concerning the other examinations to schedule.

In the event of a radiological emergency, contact the IRSN on-call engineer, 24h/24, 7d/7: +33 6 07 31 56 63



Internal contamination

The dose can be estimated from the individual internal contamination measurements. SEE SHEET 37

These individual measurements (radiotoxicological and whole-body radiation measurement analyses) allow the identification and quantification of the radionuclides that caused the contamination. **The dose received by the contaminated person can be calculated from the measured activities, the time elapsed between contamination and measurement (or sampling) and the circumstances of the accident.** The choice of the measurement(s) to take depends on the contaminating element, the contamination route (inhalation, ingestion or wound) and the time elapsed since the contamination.

The dosimetric references give an indication on the radiotoxicity of the radionuclide according to its chemical form and the exposure route.

SEE radionuclides handbook

MANAGING
THE VICTIMS

ACTION TO TAKE IN THE EVENT OF EXTERNAL IRRADIATION

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ACTION TO TAKE IN A 1ST LINE HEALTHCARE FACILITY

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ACTION TO TAKE IN A 2ND OR 3RD LINE HEALTHCARE FACILITY

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INTERNAL CONTAMINATION MEASUREMENTS AND TREATMENTS

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SHEET 13

ACTION TO TAKE IN THE EVENT OF EXTERNAL IRRADIATION

Confirming and characterising the irradiation

Responders
Medical teams: physicians and paramedical personnel[1]

Places
VAA, AMP, healthcare facility

Accidental exposure to an external source of ionising radiation (from a radioactive source which has been lost or discarded, or from an industrial irradiator, etc.) usually leads to acute or chronic irradiation. The exposure must be confirmed and characterised, and its severity must be evaluated as quickly as possible.

Two accident situations

- **Small- or medium-scale accident:** number of victims[2] < 10.
- **Large-scale accident:** number of victims[2] > 10.

The persons stop being irradiated as soon as they are taken away from the radiation source. **When at a distance from the site of the accident, treating an irradiated person involves no risk for the medical personnel.**

IN PRACTICE

If there are associated medical-surgical issues to address: the conventional emergency takes priority

From the radiological aspect, the urgency is to assess the received dose and the associated biological damage. The therapeutic response and the prognosis depend on this.

The evaluation is based on three types of dosimetry: physical, biological and clinical dosimetry (clinical signs and how they evolve over time).

SEE SHEET 15

Administering the questionnaires and determining the anamnesis without delay

This diagnostic approach serves to confirm whether there has been exposure or not and whether the irradiation of the body is total (risk of acute radiation syndrome) or partial (risk of acute localised radiation syndrome).

- **Look for the investigative elements** (circumstances of the event, dosimetric survey). They are to be looked for at the scene of the accident, otherwise they risk being lost definitively:
  - event circumstance and all useful information;
  - samples of materials useful for the dosimetric survey if necessary.
- **Fill out the questionnaires necessary for the overall evaluation of the irradiation and the medical management of each victim:**
  - describe and detail the circumstances of the accident;
  - record the physical parameters of the accident: nature of the source, type of radiation, dose, dose rate, exposure duration, distance and position with respect to the source and the shields;
  - collect any complementary dosimetric information (passive and/or operational dosimeters). This information will enable a physical dosimetry to be determined.

WHICH DOCUMENT?	WHEN?	WHERE?
Triage questionnaire	Triage of the victims	At the Victim Assembly Area (VAA) or the healthcare facility
Detailed questionnaire	If irradiation is suspected	At the Advanced Medical Post (AMP) or the healthcare facility
Medical examination questionnaire		
Medical management questionnaire	Medical management by a physician or nurse	At the AMP or healthcare facility

These questionnaires are to be filled out by a physician or, if need be, a nurse.

SEE SHEET 5

1. Depending on the number of victims, under the responsibility of a physician.
2. Guideline figure. The scale of the event will be evaluated in terms of the balance between the number of victims and the medical management capacities. If there is a mismatch, the principles of disaster medicine shall be applied.

Acute radiation syndrome (ARS)

ARS appears further to whole-body irradiation at high doses, with clinical development in four phases. Questioning is a matter of urgency.

Several clinical signs are associated with ARS, and the higher the dose received and the larger the body area concerned, the earlier they will appear. Five groups of victims named "groups I to V" are defined in decreasing order of severity. The most severe symptoms (group I) are: state of shock, cardiovascular collapse and loss of consciousness.

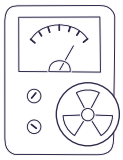
The absence of early clinical signs in the victims (group V) does not exclude the possibility of irradiation at less than 1 Gy. Hospitalisation is not indispensable, but a biological assessment must be proposed in order to confirm whether or not irradiation has occurred.

SEE SHEETS 11 15

Acute localised radiation syndrome

Acute localised radiation syndrome results from exposure of a part of the body to an external source of radiation or the deposition of radioactive particles on the skin.

The initial symptoms only appear for very high doses to the skin (the intensity and earliness of occurrence are a sign of severity: initial sensation of heat, dysesthesia, immediate pains, erythema, early oedema). Depending on the case, the initial phase is followed by a latent phase whose duration is inversely related to the dose of radiation received. The signs will appear successively according to the dose to the skin, starting with cutaneous erythema (4-5 Gy).



1. **Carry out the dosimetric evaluation:** biological dosimetry and physical dosimetric reconstruction SEE SHEET 15
2. **Conduct the paraclinical examinations:** Magnetic Resonance Imaging (MRI) and ultrasound scan of the injured zone.

The recommendations of the dosimetry and radiopathology experts of the Institute of Radiation Protection and Nuclear Safety (IRSN) enable the prescription of these examinations to be adjusted according to the lesional appearance and the dosimetric evaluations.

SEE SHEET 11

SHEET 14

ACTION TO TAKE IN THE EVENT OF EXTERNAL IRRADIATION

Guiding the diagnosis through questioning

Responders

Medical teams: physicians and paramedical personnel

Places

AMP or healthcare facility

The questioning is part of the diagnostic procedure which involves several steps and is based on specific questionnaires. The anamnesis serves firstly to confirm whether or not there has been any exposure and therefore a risk of irradiation. Then, in the event of irradiation, whether it is total (whole body) or partial.

Vomiting at an early stage is a very important sign of severity.

It is vital to determine whether vomiting has occurred.

Detailed questionnaire in cases of suspected irradiation

This supplements the triage questionnaire which is filled out for all conscious victims (rapidly identify the people closest to the event or showing early signs of irradiation).

It serves to evaluate the dose received if irradiation is suspected or when victims have been exposed to a risk of irradiation.

It comprises three parts:

- part 1: the circumstances of the accident;
- part 2: the reported disorders;
- part 3: the observed disorders.

SEE SHEET 5

If the answer to even just one of the questions is "yes", the following medical examination questionnaire must be filled out in the field (Advanced Medical Post – AMP).

Medical examination questionnaire in cases of suspected irradiation

It supplements the triage questionnaire and the detailed questionnaire.

It must be filled out for all the victims identified through the preceding questionnaires as being exposed to an irradiation risk.

It is filled out by the medical personnel at the AMP or the healthcare facility, in addition to the usual medical examination of any victim.

SEE SHEET 5

Patient's medical management questionnaire

It supplements the 2 preceding questionnaires and comprises two parts:

- part 1: the general medical management (pathology and treatment, transport and destination, medical surveillance and clinical development, taking samples, therapeutic aspects);
- part 2: radiological management (irradiation, guidance, residual external contamination with diagrams, internal contamination, measurements and samples, treatment of internal contamination).

SEE SHEET 5

IN PRACTICE

Questionnaires

Each questionnaire must be filled out accurately for each victim in the shortest possible time.

SHEET 15

ACTION TO TAKE IN THE EVENT OF EXTERNAL IRRADIATION

Evaluating the dose received

Responders
Medical teams: physicians and paramedical personnel

Places
Healthcare facility

The dose received determines the treatment. The biological dosimetry is carried out as quickly as possible once the victims are in hospital care. Physical dosimetry also provides several evaluation possibilities.

Biological dosimetry

Essential sample taking: complete blood count (CBC) and the search for chromosomal aberrations.

Analyse in priority the people likely to have received the highest level of radiation (proximity to the site of the event and clinical signs). With a person suspected of having received a significant level of radiation, it is essential to perform a blood count as early as possible.

COMPLETE BLOOD COUNT (CBC)

Lymphocytes are the most radiosensitive cells. The drop in the number of lymphocytes is directly proportional to the dose received.

LYMPHOCYTE ASSAY			LEVEL OF IRRADIATION
	After 24 hours	After 48 hours	
I	Greater than 1,500/µl	Greater than 1,500/µL	**Low** (moderate damage)
II	Between 1,500 and 500/µl	Between 1,500 and 500/µl	**Severe** (severe damage necessitating hospitalisation)
III	Less than 500/µl	Below 100/µL	**Lethal** (intensive or palliative treatment, as the case may be)

Very early hyper-granulocytosis can occur in the first few hours.

- Repeat the CBC every 4 to 6 hours for the first 48 hours and analyse locally.
- Indicate the time of sampling on each sample.

As a guideline only:

- Doses > 5 Gy: early and severe haematological alterations.
- Doses ≥ 3 or 4 Gy: the drop in the number of lymphocytes can exceed 50% of the initial value.

SEARCH FOR CHROMOSOMAL ABERRATIONS

This analysis can be carried out by a laboratory specialized in this technique, as the Institute of Radiation Protection and Nuclear Safety (IRSN) in France.

This the most sensitive biological dosimetry examination and the most specific for irradiation. It provides an accurate retrospective estimate of the received dose as from 0.1 Gy.

- If a rapid estimation of the dose is required, particularly in case of doubt concerning the interpretation of the CBCs: take a sample in the first few hours. It takes a minimum of 72 hours to obtain the result.
- In the other cases: the sample can be taken later, there is no technical urgency.

The reliability of the examination remains the same whether the sample is taken on the same day or several weeks after exposure.

Volume of the sample

- at least 15 ml of blood,
- placed in at least 2 tubes.

Procedure

Method of sampling: take the blood using an aseptic technique on lithium heparin without separator gel. Immediately shake the tube for 30 s to 1 min to ensure good mixing.

Delivery time

Deliver the sample to the laboratory without fail within 48 hours after taking the sample, accompanied by the forms provided by IRSN (to be filled out). The sample must not be frozen under any circumstances.

Transport

The sample shall be transported at room temperature (minimum: 4°C – maximum: 37°C) and protected against impacts. On the outer packaging, indicate: "Urgent biological samples – keep at room temperature".

IN PRACTICE

It is mandatory to contact IRSN before taking and dispatching any samples for chromosomal aberration analyses

IRSN duty engineer
24/24h 7/7d, in case of radiological emergency: +33 6 07 31 56 63

OTHER EXAMINATIONS

The prescribing of these examinations is to be discussed according to the type and severity of the accident, requesting the expert advice of IRSN if necessary.

EXAMINATION	INDICATIONS	REQUIREMENTS
HLA I and II tissue typing and phenotyping of erythrocytes (red blood cells)	In anticipation of a bone marrow transplant if necessary	To be performed rapidly if the estimated whole-body dose is likely to cause radiation-induced bone marrow suppression.
AMeasurement of amylase level in plasma	Indicator of irradiation of the salivary glands and the upper body	To be carried out in case of very severe and localised irradiation.
Follicle-stimulating hormone (FSH) level in plasma	Indicator of the irradiation of the gonads and lower body	To be carried out in case of very severe and localised irradiation.
Measurement of phosphorous-32 in skin appendages or sodium-24 by whole-body radiation measurement or in the blood	Estimation of the doses due to neutrons	To be carried out in the event of a criticality accident.

Physical dosimetry

READING DOSIMETERS

There are two possibilities for making a rapid evaluation in the event of an irradiation accident involving a person habitually monitored for the risk of exposure to ionising radiation:

Possibility 1: read the dose displayed on the active dosimeter.

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Possibility 2: send the passive dosimeter by express delivery to the dosimetry laboratory.

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DOSIMETRIC RECONSTRUCTION

The dosimetric reconstruction by calculation must be carried out using the physical parameters of the accident, calling upon the expertise of IRSN if necessary.

- **Gather the information** that will allow the dose to be reconstructed. SEE SHEET 5
- **Carry out the questioning as soon as possible (record and/or film if possible).** The questioning focuses on the irradiation source: radionuclide and activity in the case of sealed sources, characteristics of the irradiator (collimator, etc.), parameters of the X-ray tube or accelerator, etc. It serves to obtain a precise description of the circumstances of the accident.

The following shall be indicated at least:

- The type of radiation, the activity of the sealed source or the dose rate, the X-ray tube parameters, etc.
- The distance between the victim and the source.
- The position of the victim with respect to the source and any shielding.
- The nature (material) and dimensions of the shielding, if any.
- The different exposure sequences.
- The exposure durations for each sequence.

SEE SHEETS 5 14

RETROSPECTIVE DOSIMETRY

The techniques are based on electron paramagnetic resonance (EPR) spectroscopy and thermally or optically stimulated luminescence (TSL and OSL respectively).

- **Use the materials present in the personal effects or in the clothing** to confirm the exposure scenario and estimate the doses received by the organs or tissues.

Examples:

- Material samples that could be taken from the victims: nails, tooth enamel, etc.
- Objects carried by the victims or present in their near environment during the accident (sugars, plastics, etc.).

- **Ideally keep and list all the personal effects.** The following items can be prioritised: telephone or any other electronic object, watch, spectacles, pack of tobacco or cigarettes, sweets, medication, sugar, sweeteners. The clothes shall be kept if possible: do not wash them (follow the victim undressing procedures).
- **Indicate precisely where the samples were taken** (don't hesitate to take photos), store the samples (at ambient room temperature and preferably away from light). The dose estimations depend on the information concerning the location of the samples taken, obtained during the questioning.

IN PRACTICE

All the materials are to be sent to a specialised laboratory (IRSN in France)

IRSN duty engineer in case of radiological emergency, 24/24h 7/7d: +33 6 07 31 56 63

SHEET 16

ACTION TO TAKE IN THE EVENT OF EXTERNAL IRRADIATION

Ensuring the radiation protection of the emergency response and medical teams

Responders
Emergency response and emergency medical teams: SMUR, RRHU

Places
Exclusion zone and controlled zone

If the source of radiation is still present at the scene of the accident, the radiation protection of the emergency response and medical teams must be ensured by wearing external monitoring and alerting dosimetric equipment (active dosimeter) and by applying three protection principles: time, distance and shielding. If the environment is contaminated, protection is ensured by wearing personal protective equipment (PPE).

Implementing appropriate dosimetric monitoring for the radiological risk

These means concern the emergency response and medical teams who intervene in Radiological Emergency Situations (RES). Article R. 4451-99 of the French Labour Code defines two groups of responders:

- **Group 1 responders:** their effective dose could exceed 20 mSv during the RES. They are equipped with a passive and an active dosimeter appropriate for the situation.
- **Responders du groupe 2**: their effective dose could exceed 1 mSv, without exceeding 20 mSv. They are equipped with a passive dosimeter at least.

  If the nature of the emergency situation prevents the issue of passive dosimeters, the exposure is evaluated by any other appropriate method established by the employer with the assistance of the Institute for Radiation Protection and Nuclear Safety (IRSN). It may, for example, involve the use of an active dosimeter, collective dosimetry or an approach by calculation based on environmental measurements.

The Emergency Medical and Resuscitation Services (SMUR) of the healthcare facilities with Emergency Medical Assistance Services (SAMU) have active dosimeters (since 2005).

PASSIVE DOSIMETER

Generally speaking, the dosimeters used and worn on the chest under the PPE are suitable for the types of radiation likely to be encountered: X-rays, gamma and/or beta rays, neutrons. Extremity dosimeters and eye lens dosimeters can also be worn if necessary.

Use:

- Personal and nominative dosimeter.
- Dosimetric measurement during the emergency period.
- The dosimeter analysis cycle usually takes several days (dispatch to laboratory, analysis, return), but can be expedited if necessary.

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IN PRACTICE

Stock available in case of emergency

IRSN holds a permanent stock of several hundred dosimeters which can be issued immediately at the request of the public authorities in the event of a crisis.

ACTIVE DOSIMETER (ELECTRONIC)

Characteristics:

- Continuous real-time display of the dose accumulated since the start of the operation.
- Visual or audio alarm system with adjustable threshold.

Use:

Real-time measurement and display of the dose received for self-checking purposes.
This a device which alerts the user and optimises radiation protection. The responder is alerted about the dose rate and the cumulative dose received since the start of the operation.

- Protect the dosimeter from external contamination by placing it in a small zip lock plastic bag. If it is equipped with a beta radiation sensor, keep this sensor visible for better measurement of the dose received.
- Wear the dosimeter at chest height (if this is impossible, wear it on the belt) and such that the alarms can be detected.
- It may not be possible to wear it under the protective equipment usually recommended for dosimetry. In this case, the employer decides how the dose received by the worker is determined from the exposure measurement.

Technical information to verify with an electronic dosimeter:

- Suitability for the types of radiation likely to be encountered: X- and gamma-ray energy levels higher than 15 keV, average beta-ray energy levels higher than 100 keV.
- Visual or audio alarm systems.

A procedure for the periodic verification (annual) of the radiation protection instrumentation must be put in place so that the devices are always ready to function optimally (check of power supplies, verification of the energy range and the dose and dose rate measurement ranges, verification of their measurement performance).

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SHEET 17

ACTION TO TAKE ON THE SITE OF THE EVENT

Carrying out the initial first-aid measures

Responders
- Emergency response teams: FRS
- Emergency medical teams: SMUR, RRHU
- Internal security forces

Places

Exclusion zone and controlled zone

The appropriate vital actions and emergency techniques must be applied to the casualties immediately: medical-surgical urgencies always take priority, whatever the level of contamination.

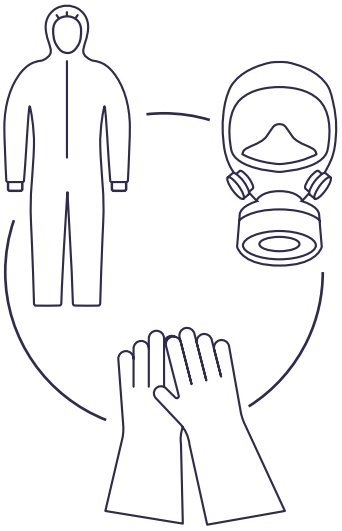
Responders entering an exclusion zone must be suitably protected. The first reflex is to evacuate the victim from the danger zone. If there is no physician at the scene, this is usually done by the first-aid responders, who are trained and practised in performing the reflex actions.

1 Protect the responders

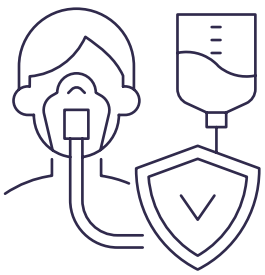
Radiological or nuclear agents (RN) can cause internal and/or external contamination. **The emergency response and medical teams must protect themselves.**

- Identify the appropriate dress for each zone, after consulting the RN risk advisors, for all the responders on the scene (emergency teams, Emergency Medical and Resuscitation Service – SMUR, Rapid Response Health Units - RRHU, Internal Security Forces – ISF, etc.).

SEE SHEET 22



2 Protect the victims against internal contamination



This constitutes a reflex action in the same way as the lifesaving actions.

- Protect the airways: the means are provided in the Civil Security "VAA CBRN" kits. If these kits are not available, use a respiratory mask, a dust mask, a handkerchief, etc.
- Some manual insufflators (Bag Valve Masks – BVM – with one-way valve) offer this protection possibility (no standardised thread for cartridge).
- Put assisted ventilation in place if necessary, favouring pure oxygen ventilation if possible.
- Do not eat, drink or smoke. Apart from the administration of the appropriate treatments, eating, drinking and smoking are prohibited, including in support zones.

3 Evacuate to the controlled zone, ensuring the necessary lifesaving actions

- **Evacuate the victim(s) as rapidly as possible to the controlled zone,** to the Victim Assembly Area (VAA).
  - This reflex action must be carried out by the emergency responders.
  - Very occasionally this action might require the presence of a physically trained physician equipped with appropriate protective equipment.
- Carry out the lifesaving actions on the spot (**medical-surgical urgencies take priority over radiological contamination**).
- Stabilise the victims, making sure not to delay their transfer to the healthcare facility.

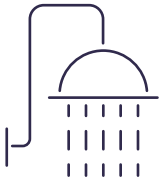
SEE SHEET 20

Characteristics of the controlled zone

- Lower level of contamination and/or irradiation (ideally, zone close to the background radiation level).
- Lower level of danger (landslide or structural collapse, explosion, smoke, ballistic projection).
- Accessibility of the emergency response teams, particularly the medical response teams.

SEE SHEET 18

4 Treat the contaminations as rapidly as possible



The faster the treatments are applied (before transfer to the healthcare facilities), the more effective they are.

TYPE OF CONTAMINATION	IMMEDIATE TREATMENT TO APPLY
External (skin)	Shower and non-aggressive washing SEE SHEETS 24 to 26
Internal	Antidotes SEE radionuclides handbook + SEE SHEETS 27 + 38 to 40

5 Evaluate the dose received by the victim in the event of irradiation

- First confirm and characterise any exposure to a source of irradiation: **total or partial irradiation of the body.**
- Then evaluate the severity as quickly as possible: **question the victim and gather the investigative elements** (circumstances of the event, dosimetric investigation) on the site of the accident.

SEE SHEETS 5 11 + 13 to 15

Action to take in the case of irradiated or contaminated lesions

Acute irradiation and/or contamination associated with traumatic injuries (fractures, injuries, wounds, burns) aggravate the prognosis of the lesions. The trauma potentiates the effects of the lesion and *vice versa*.

In practical terms, whole-body irradiation increases the risk of cardiovascular shock, infection and haemorrhage, and slows down the healing of wounds and consolidation of fractures.

- **Medical care:**
  - control any severe bleeding[3];
  - free the airways and ensure correct ventilation;
  - maintain the circulatory function.
- **Once the condition of the casualty is stabilised:**
  - apply the decontamination and internal contamination treatment processes;

    SEE SHEETS 24 to 27 + 34 + 38 to 40
  - collect the data for diagnosing external irradiation severity.

    SEE SHEETS 5 + 13 to 15

If a diagnostic or therapeutic intervention is necessary: schedule it for as soon as possible, but after the initial syndrome period.

Implement early shock and infection prophylaxis.

3. Do not forget to perform HLA tissue typing before transfusing if necessary.

SHEET 18

ACTION TO TAKE ON THE SITE OF THE EVENT

Organising the medical pathway of the victims in the 3 zones

Responders

- Emergency response teams: FRS
- Emergency medical teams: SMUR, RRHU
- Medical and pharmaceutical teams (if Mobile Medical Station – MMS – kits and antidotes are present)
- Internal security forces

In a radiological or nuclear (RN) emergency, the Civil Protection Service puts in place the zoning system which comprises three zones: an exclusion zone, a controlled zone and a support zone. The aim of this organisational set-up is to treat as many victims as possible. It is governed by Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 2011[4].

The organisation follows the go-forward principle:
the victims go from the most contaminated zone (exclusion zone) towards a clean zone (support zone), WITHOUT any possibility of backtracking. The level of radiological risk and personnel protection differ from one zone to the next. The protection is specific to each zone.

EXCLUSION ZONE

The zone closest to the event, reserved for evacuation of the victims.

- Only emergency medical actions performed by a medical professional wearing appropriate Personal Protective Equipment (PPE) can be carried out in this zone.

CONTROLLED ZONE

Reserved for prehospital medical care and triaging of the victims and uninjured persons (Victim Assembly Area – VAA RN).

Triaging by emergency responders is done visually. It is followed by medical categorisation.

- The victims are divided up according to their classification: **able-bodied, incapacitated, Extreme Urgencies (EU).**
- **Transfer of victims out of zone**: only the victims identified as EU cases requiring medical-surgical treatment are transferred directly to a 1st line healthcare facility which has been duly informed by the regionally competent SAMU (medical regulation). Unlike the other victims, EU victims do not go through a decontamination shower.
- **Uninjured persons** go through the portable radiological contamination portal monitor (see page 61) or any other available device that can detect external contamination.

As a complement to the Civil Protection Service response, the emergency medical aid mobilises the medical skills and resources of the SMUR and RRHU to ensure the medical care of the patients at the VAA.
The victims are counted in the field using the SINUS application implemented by the Civil Protection Services.

WHO DECIDES ON THE TRANSFER OF EU CASES?

The decision falls upon the Emergency Operations Commander (EOC) and the Medical Operational Coordinator (MOC), with the regionally competent SAMU. The SAMU is responsible for organising the patient's medical care pathway and their transfer by ambulance to the receiving healthcare facility.

SUPPORT ZONE

Reserved for the medical care and stabilisation of the victims after full decontamination.

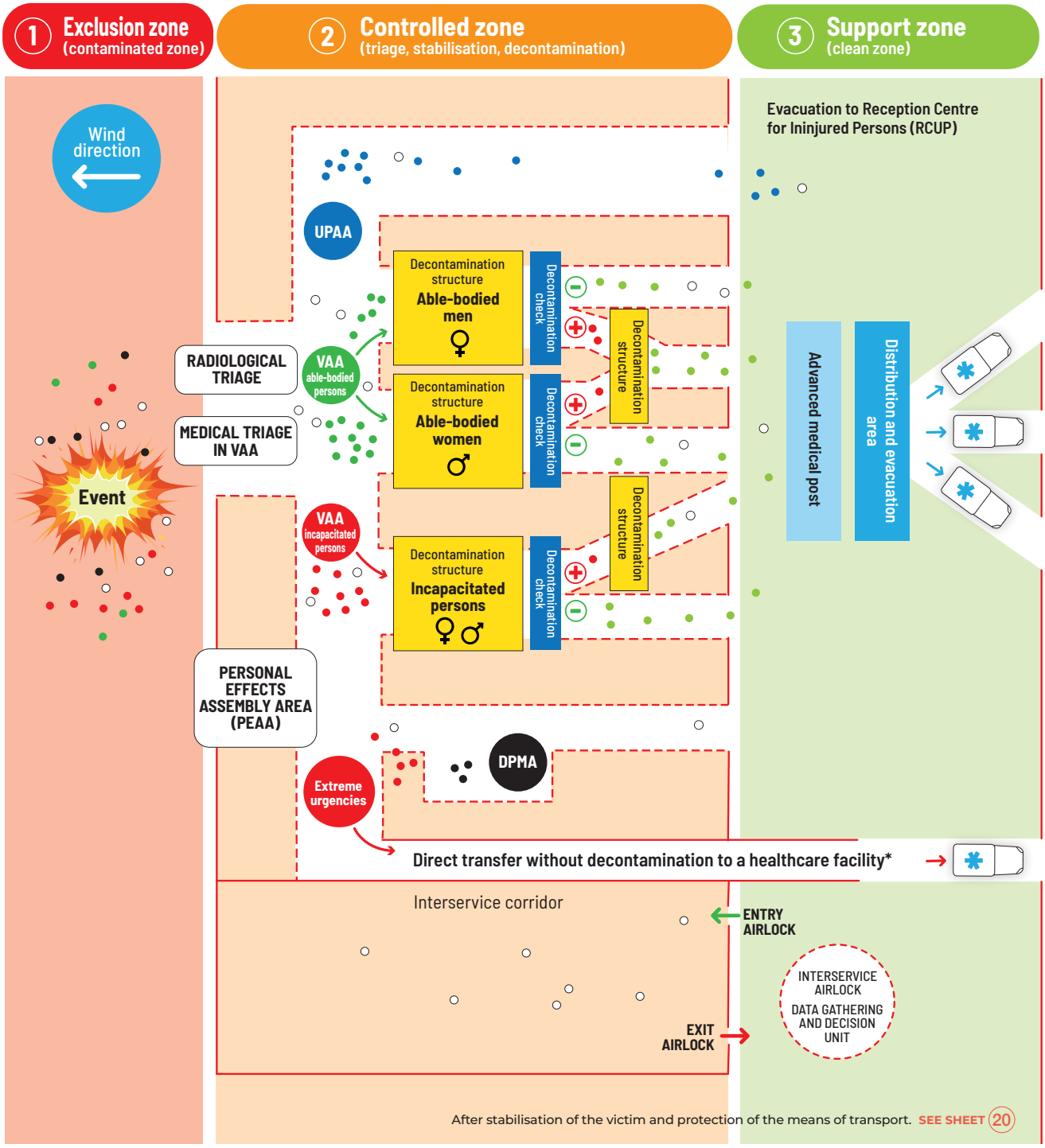
The exercises and training sessions, particularly the interministerial zonal training sessions serve to test the operational readiness of the set-up and the services.

4. Circular relative to the national doctrine concerning the use of emergency and medical care resources in the event of a terrorist attack involving radioactive materials.

DIAGRAM No. 2

General organisation of the response in a nuclear or radiological emergency

Diagram taken from Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 2011 on the French national doctrine for the use of emergency rescue and medical care services in response to a terrorist attack involving radioactive materials.



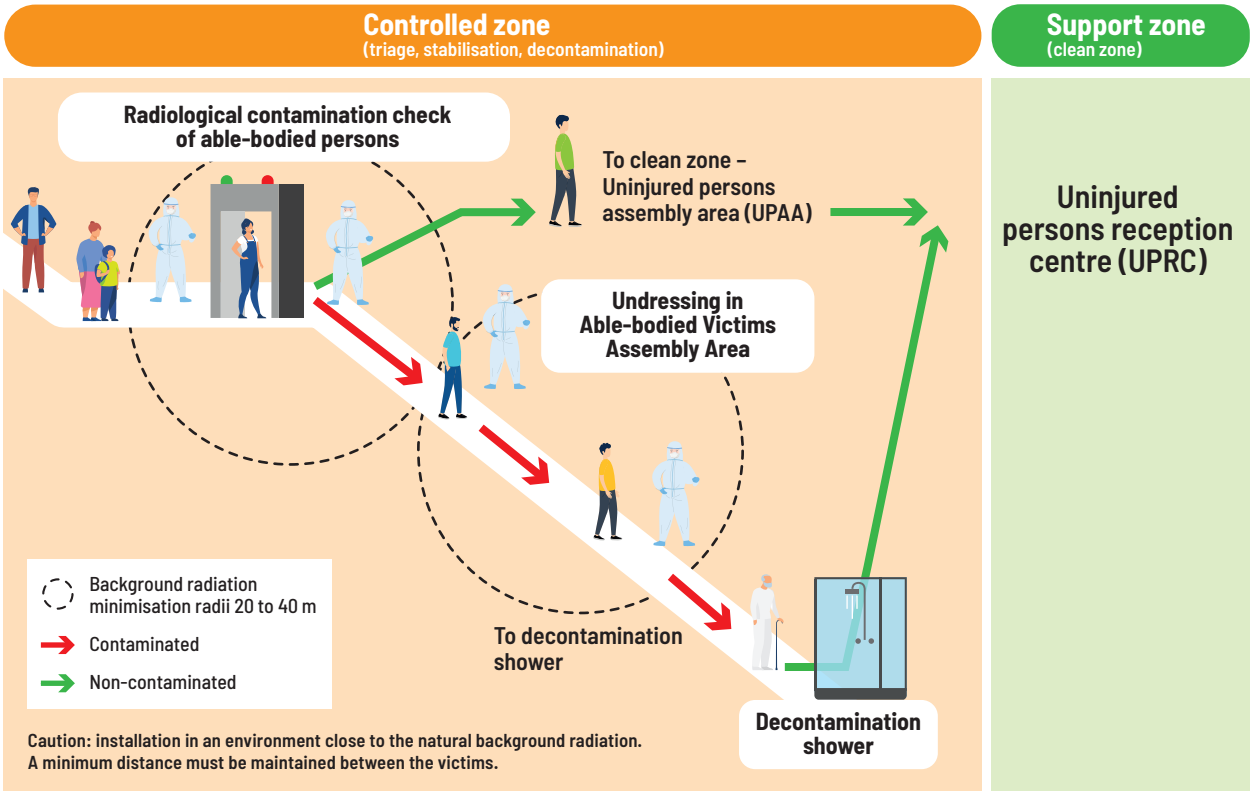
DPMA: Deceased Persons Management Area
PEAA: Personal Effects Assembly Area

UPAA: Uninjured Persons Assembly Area
VAA: Victim Assembly Area

- Uninjured victims without symptoms
- Able-bodied victims with symptoms
- Decontaminated victims
- Incapacitated victims with symptoms
- Deceased victims
- Medical team personnel

DIAGRAM No. 6

Triage of able-bodied persons by the portable radiological contamination portal monitor



Civil protection and public health resources

The civil protection and public health response is based on interservice training sessions in the defence zones and on the equipment specific to the Chemical, Biological, Radiological and Nuclear risk (CBRN risk), held across the French territory as a whole:

- Mobile Radiological Response Units (MRRU[5]).
- Portable radiological contamination portal monitors.
- Mobile Decontamination Unit – MDU (see diagram 7 on next page).
- Antidotes, victim undressing and redressing kits, bags for stowing their personal effects: designated "VAA CBRN" kits.
- Means of detecting and identifying chemical and radiological products.
- Mobile Medical Stations (MMS) 1 and 2 containing the antidotes in particular, paediatric MMSs.
- If necessary, mobile bioassay measurement means for measuring internal contamination can be deployed at the UPAA. SEE SHEET 37

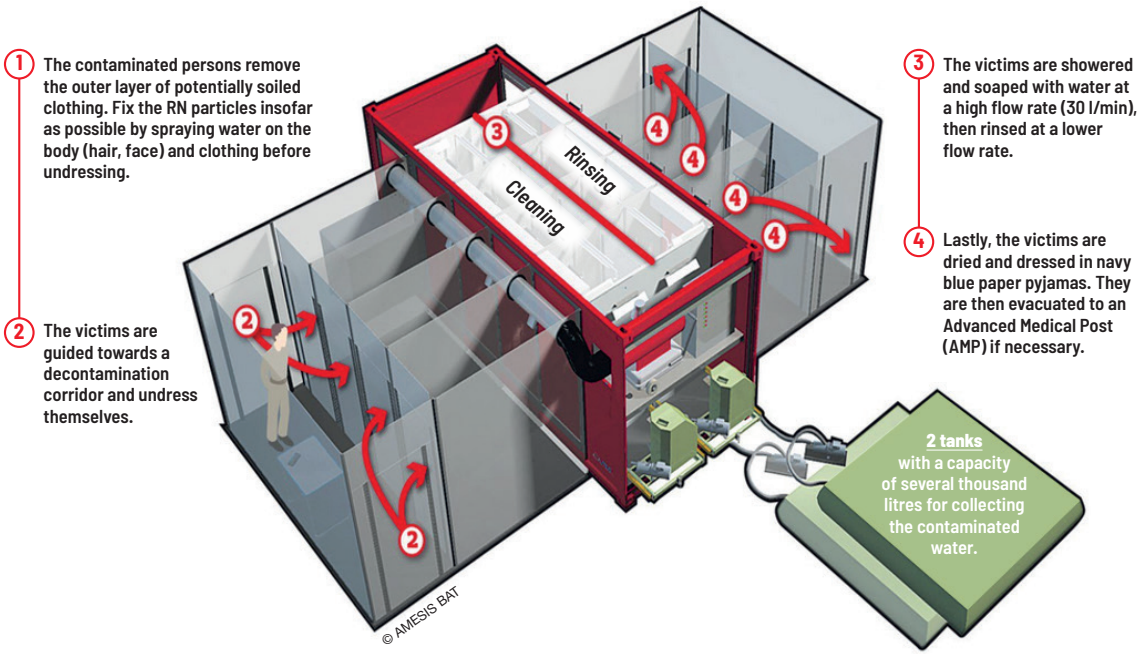
5. There are 29 MRRUs in France and about 50 reconnaissance teams with appropriate means for detecting radiological contamination.

Portable radiological contamination portal monitor.

External contamination detection devices.

DIAGRAM No. 7

Mobile decontamination unit – MDU (shower)



SHEET 19

ACTION TO TAKE ON THE SITE OF THE EVENT

Organising the relief work

On the site of the event, the emergency response teams manage the alert, intervene in the prehospital organisation and medical regulation, in application of Circular No. 800/SGDSN/PSE/PPS of 18 February 2011[6].

The alert

Responders	The steps
• CRRC + APC • Emergency services call centre (15-17-18-112)	**RECEIVE AND ANALYSE THE ALERT** to identify the potential radiological or nuclear (RN) threat: to be carried out **as rapidly as possible** on the basis of the information obtained from the calls.
• CRRC + APC in relation with the other interconnected services	**ASSESS THE SERIOUSNESS OF THE SITUATION** more specifically through an inter-service conference so that they all have the same level of information. Inform the Prefecture and the Regional Health Agency.
• CRRC + APC • SMUR + RRHU • Specialised teams (management of children)	**MOBILISE THE EMERGENCY RESPONSE, MEDICAL AND LAW ENFORCEMENT SERVICES** **as soon as the alert is received,** on the basis of the qualitative and quantitative information gathered by emergency call centres: the Call Reception and Regulation Centre (CRRC) and the Alert Processing Centre (APC). **If children are present among the victims, specialised teams must be mobilised rapidly** (paediatric SMUR, all-round SMUR with paediatric capabilities, life support ambulances and radio-equipped medical vehicles of the Fire and Rescue Services – FRS) and appropriate means of medical management.
• Zone Operational Centre (ZOC) of the zone Prefecture • Zone Regional Health Agency • Zone SAMU	**RAMP UP THE RESOURCES** in the context of the Interministerial Circular No. 800/SGDSN/PSE/PPS of 18 February 20116, of the "Organisation of the Civil Protection Response – Numerous Victims" plan (Orsec NOVI) and the regional application of the governmental "Chemical, Biological, Radiological, Nuclear" plan. • **At the request of the Emergency Operations Commander (EOC).** • **In collaboration with the Medical Operational Coordinator (MOC).**

Prehospital organisation

The emergency response and emergency medical care in an RN context enter into the field of competence of emergency relief and emergency medical services. They are dispensed according to the medical care needs of the victims from the controlled zone to the support zone.

The victims receive medical care as early as possible (except in the exclusion zone).

6. Circular relative to the national doctrine concerning the use of emergency and medical care resources in the event of a terrorist attack involving radioactive materials.

Responders	The steps
• SAMU • FRS	**DEPLOY THE APPROPRIATE OPERATIONAL AND REGULATION PROCEDURES FOR THIS TYPE OF EVENT** • **Identification of the medical teams** of the SMUR and the Rapid Response Health Units (RRHUs) who can intervene in controlled zones. • **The decontamination of people, whether injured or not,** is the responsibility of the specialised units of the Fire and Rescue Services (FRS) and is carried out at the scene of the event or in the immediate vicinity.
• SMUR • RRHU likely to intervene in controlled zones	**TAKE CARE OF THE VICTIMS** without endangering oneself and using the necessary Personal Protective Equipment (PPE). **Strategy for providing emergency medical care in the controlled zone.** • It depends on the nature of the radionuclide involved. • It is organised jointly by the Chief Physician and the Fire Brigade Officer responsible for the Victim Assembly Area (VAA), in collaboration with the COS and the MOC. • It takes account of the availability of trained and physically prepared FRS and SMUR personnel, equipped with suitable protection (PPE and dosimeters), having the appropriate specific logistical and therapeutic resources. • Equipment of the SAMU and SMUR teams: they are equipped with Mobile Medical Stations (MMS) 1 and 2 containing antidotes / radionuclide chelating agents, and paediatric MMSs. • Equipment of the Fire and Rescue Services (FRS) of large conurbations: they are equipped with "VAA CBRN" kits containing medical equipment and health products.

Medical regulation

Responders	The steps
• MOC • Regionally competent SAMU	**DIRECT AND DISPATCH TO THE APPROPRIATE HEALTHCARE FACILITIES, ON THE BASIS OF THE VICTIM CATEGORISATION** Absolute Urgencies (AU), including Extreme Urgencies (EU), and Relative Urgencies (RU). In the face of a mass casualty RN emergency, each casualty must receive the requisite specialised care (aim: **provide damage control care**). SEE SHEET 4
• MOC • Regionally competent SAMU	**APPLY A VICTIM MANAGEMENT STRATEGY (MASS CASUALTY RATIONALE)** • **Collection and analysis the initial data**, more specifically: information resulting from inter-service communication bringing together the arguments in favour of an RN event. • **Alerting of the teams on the ground regarding suspicion of the RN risk** implying the wearing of appropriate personal protective equipment. • **Identification of the severity criteria** for an initial quantitative (adults/children) and qualitative assessment of the victims, according to the described injuries and symptoms. • **Mobilisation of the SMUR and RRHU teams** (trained teams with appropriate PPE) in accordance with the predetermined operational procedure. • **Alerting** of the Regional Health Agency, the Director of the SAMU head office healthcare facility, the zone SAMU, the SAMUs bordering the Reference Regional Hospital for the RN risk (RRH RN), and the 1st line healthcare facilities.

Medical regulation (cont'd)

Responders	The steps
• Regionally competent SAMU with the support of the zone SAMU and the RRH RN	**DISPATCH THE VICTIMS AMONG THE HEALTHCARE FACILITIES:** 1st line and, if necessary, 2nd line facilities. Choice of facility based on the balancing of several criteria: • **Condition of the victim.** • **Accommodation and treatment capacities for children** (according to age) or adults. • **Technical platform,** particularly for specific treatments (severe injuries, poisoning, burns, irradiation, contamination by radionuclides, etc.). *The capacity of the 1st line healthcare facilities is determined beforehand by the Regional Health Agency under the "Organisation of the Healthcare System Response in Exceptional Public Health Situations for the Chemical, Radiological and Nuclear Risk" (Orsan CRN).*

CHILDREN: HOW ARE THEY TO BE MANAGED?

As with any other accident involving many people, the presence of children necessitates the mobilisation of appropriate and previously identified medical resources. The strategy for the medical management of children is similar to that for adults. The particularities of child medical management are covered by professional recommendations published under the auspices of the French Society of Emergency Medicine.

Mobilising reinforcements

Responders	The steps
• Regional Health Agency of the defence zone	**MOBILISE THE AVAILABLE REGIONAL RESOURCES** to have reinforcements in the defence and safety zone (zonal plan for mobilising healthcare resources): • human and material resources, • healthcare products (medicines, including the radionuclide antidotes/chelating agents and oxygen).
• CORRUSS-CCS • Armed forces health service (exceptional situations)	**MOBILISE NATIONAL REINFORCEMENTS** The national reinforcements can be mobilised alongside the regional resources by Operational Centre for Regulation and Response to Health and Social Emergencies – Health Crisis Centre (CORRUSS-CCS – national Orsan arrangement), possibly in collaboration with the Armed Forces Health Service[7] (SSA). • **Health agencies,** in particular the Institute for Radiation Protection and Nuclear Safety (IRSN). • **Tele-expertise** for assisting with the care of contaminated victims, especially children, by non-specialised teams confronted with this type of emergency. • **Projection of national medical teams** (SMUR, RRHU, radiotoxicology specialists, etc.) or healthcare products (strategic stocks of radionuclide antidotes/chelating agents) and other equipment. • **Mobilisation of exceptional medical evacuation capabilities:** ambulances, trains, buses, aircraft, boats, etc.

7. The SSA is only called upon in exceptional situations, when civil resources are inexistent, insufficient, inappropriate or unavailable.

SHEET 20

ACTION TO TAKE ON THE SITE OF THE EVENT

Before evacuation: stabilising and preparing the victims

Responders
- Emergency response teams: FRS
- Emergency medical teams: SMUR, RRHU

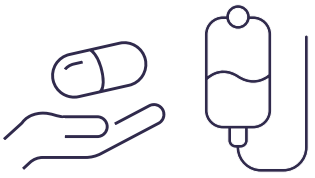
Places
Controlled zone

The victims with external contamination are prepared for emergency decontamination at the scene of the event. But this must not delay the evacuation of the most seriously affected victims.

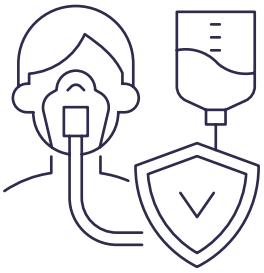
Medical-surgical urgencies take priority over contamination and irradiation.

1 Take the technical actions: first resuscitation measures

These are conventional medical measures to prepare the victim for evacuation from the site (peripheral venous route, if necessary, check of the airways, administration of treatment if necessary, etc.).



2 Prepare the victims



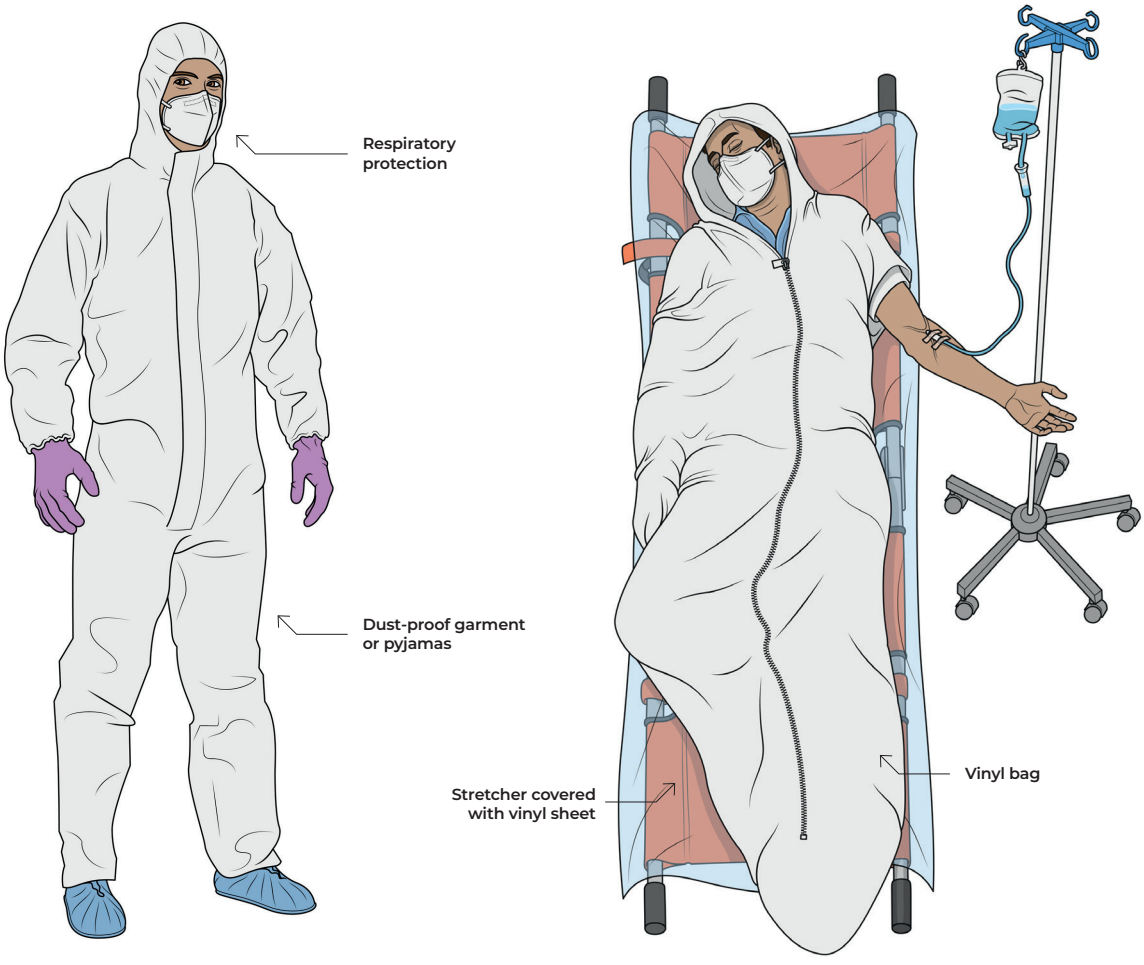
The aim of this "radiological" preparation before leaving the zone is to avoid any transfer of contamination: the dissemination of contamination must be kept to the lowest level possible.

- After cleaning the face, **protect the victim's upper airways** by placing an FFP3 mask or, failing this, an FFP2 mask on their face.
- **Limit the spreading of contamination:** remove the outer clothing or, if this is not possible, confine the radionuclide(s) deposited on the clothing (without passing over the head) and put a surgical cap on their head. Radionuclides must not be put back into suspension in the surrounding environment (spray water to fix the dust).
- **Protect the evacuation stretcher**: with a vinyl sheet for example.

The procedures must be adjusted according to the condition of the victim: able-bodied or incapacitated (see diagrams on next page).

The emergency decontamination is then carried out by the emergency response services (fire brigade) or the medical personnel (SAMU, SMUR and RRHU), who take care of these victims at the Victim Assembly Area (VAA).

VICTIM PREPARATION DIAGRAMS



Single envelope technique

Able-bodied victims

These actions are carried out in the VAA by the fire brigade:

- able-bodied victims must put on a dust-proof garment (garment type 5-6) after removing at least the outer layer of clothing; SEE SHEET 33
- **make sure that the upper airways are protected** by a type FFP3 mask or, failing this, an FFP2 mask;
- **the victims are then evacuated and guided,** by duly trained personnel, to the Mobile Decontamination Units (MDUs).

Incapacitated victims (lying down)

Use the single envelope or double envelope technique (see diagram on next page).

The double envelope technique is used for victims who are to be transferred directly to a healthcare facility. These victims need to be transported and cannot be decontaminated beforehand.

Single envelope technique

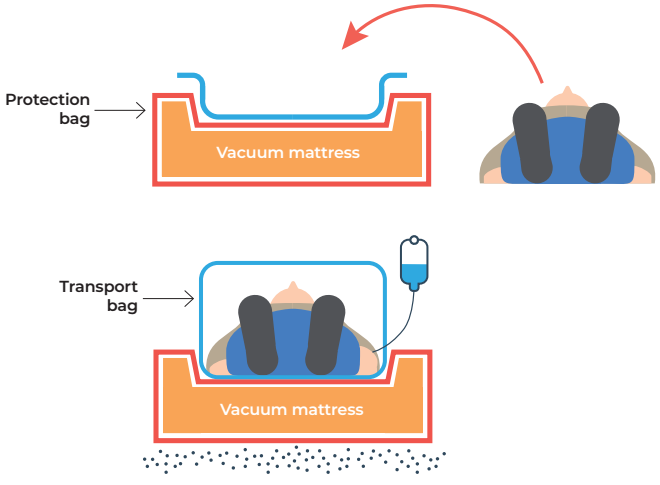
1. Before entering the controlled zone, cover the stretcher with a sheet of vinyl.
2. Position the stretcher near the victim and place an open vinyl bag on the stretcher.
3. Lift the victim using the conventional techniques and place the victim in the bag, close the bag leaving the head and arms free (infusion, monitoring blood pressure).

Double envelope technique

A vacuum mattress is required.

1. Before entering the controlled zone, wrap the vacuum mattress in a vinyl sheet. Ideally, use a protective vinyl bag.
2. Position the vacuum mattress near the victim. Place a second vinyl sheet or a second vinyl bag (transport bag) on the vacuum mattress.
3. Lift the victim using the conventional techniques and place them in the transport bag, close the bag leaving the head and arms free (infusion, monitoring blood pressure).
4. Place the vacuum mattress under negative pressure.
5. Cut away the vinyl sheet surrounding the vacuum mattress and leave it on site..

The double envelope technique must be perfectly mastered to avoid losing time. It must never hinder the treatment of an Absolute Emergency (AU).



PROTECTION ACCESSORIES

- **Transport bags** for the patients, the vacuum mattresses, the stretchers.
- **Protective vinyl sheets** for the ambulances, walls.
- **Dust-proof garments** of category III, type 5-6, double pair of gloves, respiratory protection (FFP3 mask or, if not available, FFP2 mask) and surgical cap.

SHEET 21

ACTION TO TAKE ON THE SITE OF THE EVENT

Evacuating the injured: leaving the controlled zone

Responders
- Emergency response teams: FRS
- Emergency medical teams: SMUR, RRHU

Places
Controlled zone

Evacuation from the controlled zone may involve transportation in a vehicle. The decontaminated injured victims may be directed to a temporary care structure (Advanced Medical Post – AMP) or to a healthcare facility in the appropriate medical pathway for their category (Absolute Urgencies – AU/Relative Urgencies – RU) after medical regulation. The extreme urgencies (EU) are transferred directly without decontamination to a healthcare facility which has been informed beforehand, with the approval of the Medical Operational Coordinator (MOC).

Medical-surgical urgencies take priority over contamination and irradiation.

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Method of evacuating the injured

MEASURES TO TAKE FOR THE VEHICLE	MEASURES TO TAKE FOR THE CASUALTIES	MEASURES TO TAKE FOR THE TEAMS

Extreme Urgencies (EU)

MEASURES TO TAKE FOR THE VEHICLE	MEASURES TO TAKE FOR THE CASUALTIES	MEASURES TO TAKE FOR THE TEAMS
If the medical ambulance enters the contaminated zone: · preparation that is recommended but not mandatory (it must never cause a loss of time): line interior with vinyl sheeting; · to avoid transferring contamination from the controlled zone to the support zone, the victim is transferred to another vehicle. The contaminated ambulance remains in the controlled zone and might possibly be used in this zone.	**Use of the double envelope technique.**	**Protection by Personal Protective Equipment (PPE).** **Before getting into the evacuation vehicle:** change gloves and put on a new pair of overshoes. **On arrival at the healthcare facility:** avoid having the teams enter the facility (relay team if this does not cause a loss of time).

Absolute Urgencies (AU) evacuated directly to a healthcare facility

MEASURES TO TAKE FOR THE VEHICLE	MEASURES TO TAKE FOR THE CASUALTIES	MEASURES TO TAKE FOR THE TEAMS
If the medical ambulance enters the contaminated zone: · preparation that is recommended but not mandatory (it must never cause a loss of time): line interior with vinyl sheeting; · to avoid transferring contamination from the controlled zone to the support zone, the victim is transferred to another vehicle. The contaminated ambulance remains in the controlled zone and might possibly be used in this zone.	**Leaving the zone: after "radiological" preparation.** SEE SHEET 20 Risk of transferring contamination: · low; · virtually zero if the double envelope technique is used. **Before transferring to the evacuation vehicle:** · cut away the protective cover along the upper edge of the vacuum mattress; · leave the lower part of the contaminated protective cover where it is; · place the non-contaminated vacuum mattress on the evacuation vehicle stretcher.	**Before getting into the evacuation vehicle:** change gloves and put on a new pair of overshoes. **On arrival at the healthcare facility:** avoid having the teams enter the facility (relay team if this does not cause a loss of time).

Absolute Urgencies (AU) who can go through decontamination without loss of chance of survival, and Relative Urgencies (RU)

As these victims must be decontaminated before they are evacuated, no particular evacuation measures are required.

GATHERING INFORMATION

Any casualty evacuated to an AMP or a healthcare facility is given a personal prehospital card indicating the relevant medical information and a SINUS bracelet for medical management purposes.
SEE SHEET 5

SHEET 22

ACTION TO TAKE ON THE SITE OF THE EVENT

Protecting the responders in the exclusion zone and the controlled zone

Responders
- Emergency response teams: FRS
- Emergency medical teams: SMUR, RRHU

Places
Exclusion zone and controlled zone

The rule for the first responders at the scene of the event is to ensure that they themselves have the maximum level of protection until the environmental hazards have been identified.

Protect the emergency response and emergency medical teams (SMUR and RRHU)

The professionals who are required to approach the closest to the scene of the event wear appropriate garments for intervention in a hostile environment according to the zone in which they are situated (see table below).

Exposure of the response teams to the radiological risk must be avoided or kept to the lowest level possible.

ZONE	ÉQUIPMENT[8]
① Exclusion zone	• First-line Personal Protective Equipment (PPE) offering maximum protection with breathing apparatus with filter ("Chemical, Biological, Radiological, Nuclear" (CBRN suit permeable to air) and mask with CBRN filter cartridge. • Once the chemical risk has been dispelled, appropriate PPE for the radiological and nuclear – RN) risk (non-woven paper coverall + FFP3 mask or, failing this, FFP2 mask + safety glasses + overboots + gloves).
② Controlled zone	Mask with cartridge filter or FFP3 mask or, failing this, FFP2 mask, non-woven paper coverall type 5-6, safety glasses, surgical cap if the coverall has no hood, overboots and gloves.
③ Support zone	No particular protective garments required.

SEE SHEET 6

8. See INRS sheets: "Personal protective equipment", ED 6077 (https://www.inrs.fr/media.html?refINRS=ED%206077) and "Protective garments", ED 995 (https://www.inrs.fr/media.html?refINRS=ED%20995).

Protect responders in the exclusion zone and the controlled zone

3 principles

1. Only duly trained emergency response and emergency medical assistance teams protected against the risk of external and internal contamination and equipped with dosimeters may enter these zones, which are delimited beforehand.
2. The victims must be protected against the risk of internal contamination.
3. Medical-surgical urgencies take priority over contamination and irradiation.

Evaluate the risk

The risk evaluation is limited to determining the contaminating agent(s), if this is possible.

If the nature and level of risk can be refined, the wearing of recommended Personal Protective Equipment (PPE) can be adapted accordingly.

Get suitably equipped

- **Interventions in controlled zone**

The personnel of the Mobile Emergency and Resuscitation Services (SMUR), the Fire Brigade (FB) personnel of the Fire and Rescue Services (FRS), including the Rapid Response Health Unit (RRHU) and the Mobile Radiological Response Units (MRRU) personnel and the Internal Security Forces (ISF) are trained to intervene **in controlled zones at the Victim Assembly Area (VAA).**

They are equipped with a CBRN suit that is permeable to air and a cartridge filter CBRN mask affording P3 protection.

After dispelling any doubt about a chemical (C) risk and if decided by the Emergency Operations Commander (EOC), the PPE may be adapted: mask with cartridge filter or FFP3 mask or, failing this, FFP2 mask, non-woven paper coverall type 5-6, safety glasses, surgical cap if the coverall has no hood.


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- **Interventions in exclusion zone**

The FB personnel of the FRS, and the MRRU personnel in particular, are trained and equipped to intervene **in exclusion zones**. Their PPE is adapted to the type of risk encountered.

In situations of life-threatening emergency, the SMUR and the FRS RRHU personnel can also intervene in exclusion zones if they have appropriate PPE.

RISKS	EQUIPMENT FOR RESPONDERS IN THE EXCLUSION ZONE
Radionuclide in form of aerosol, vapour or gas Protect the upper airways	**Mask:** full-face mask respirator with filtering cartridge, OR full-face filtering mask with appropriate cartridges (in case of doubt about the presence of radionuclides in vapour or gas form). **Dust-proof garment of category 3 type 5-6:** garment with hood and overboots. **Gloves:** under all circumstances the hands are protected by two pairs of disposable nitrile gloves.
Radionuclide diffusible by transcutaneous route Example of a radionuclide that diffuses very easily: tritium	**Special sealed and pressurised coverall.** This type of coverall must be worn when entering a confined environment contaminated with radionuclides of this type.
Associated risk of irradiation The exposure time must be as short as possible and the human resources can be organised to allow "sharing of the doses". It is difficult to plan for a dose limit when it is a question of saving a human life. Nevertheless, the regulations set a reference level of 500 mSv[9] for this exceptional situation.	**Active dosimeter with a triggering threshold and an alarm system.** It is vital to wear it to avoid exceeding the reference level of 100 mSv for the group-1 personnel in a radiological emergency. It is recommended to set the alarm threshold to a single value, whether in terms of cumulative dose or dose rate (2 mSv and 2 mSv/h, for example). ***Action to take in the event of an alarm:*** *- read the displayed values and inform the competent and previously designated services so that they can give advice and evaluate the level of exposure more precisely;* *- move away from the source if the dose rates are too high (level to be defined).* **External dosimetry devices** SEE SHEET 16

On leaving the controlled zone

All the people who have been working in a contaminated zone (exclusion and controlled zones) must be checked at the interservices airlock.

Exit airlock (interservices airlock)

It is mandatory for the responders to leave the zone *via* an interservices airlock, complying with the checking and undressing protocol. The airlock must be installed in a place where the level of radioactivity is equal to the background radiation of the device used.

NECESSARY EQUIPMENT

- **Detectors of alpha, beat and gamma radiation**, counter and ratemeter of the Geiger-Muller or scintillator type (with narrow window).
  SEE SHEET 32
- **Square vinyl sheets**, 2 m^2.
- **Bin bags**, 350 litres.
- **Dustbin support** with bin bags.
- **Three pairs of Jesco scissors.**

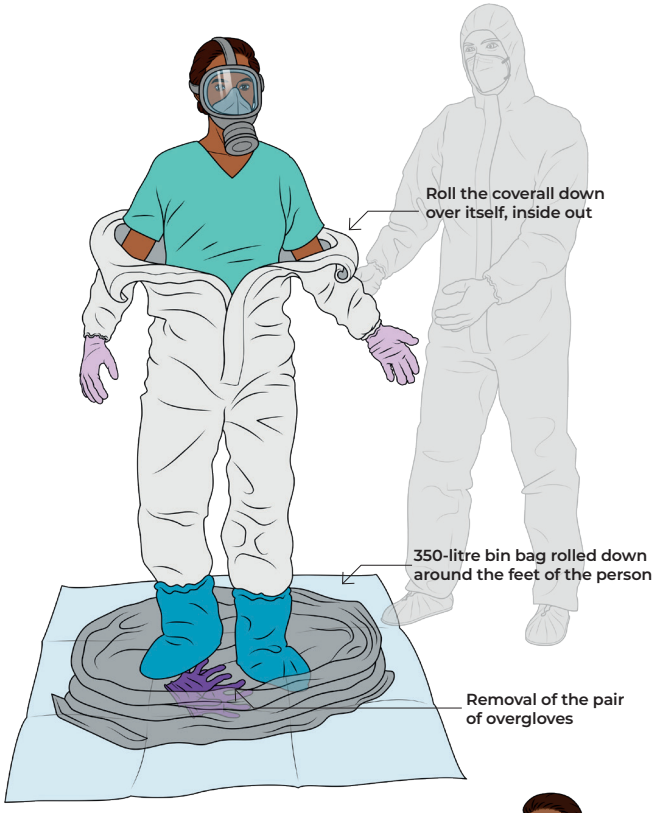
GARMENTS WORN BY PERSONNEL AT EXIT AIRLOCK

- **Non-woven coverall** category 3 type 5-6, with hood.
- **Overboots** in non-woven material with non-slip soles.
- **Respiratory protection** with an FFP3 mask or, failing this, an FFP2 mask.
- If concerns about a chemical risk have not been dispelled or if radionuclides are present in vapour or gas form, **CBRN coverall permeable to air and mask with CBRN cartridge affording P3 protection.**
- **Safety glasses** (unless a full-face mask is worn).
- **Two pairs of nitrile or latex gloves** complying with standard EN 421 (gloves providing protection against ionising radiation and radioactive contamination): join the first pair of gloves to the sleeves of the paper coverall with adhesive tape.

9. Article R. 4451-11 of the French Labour Code.

PERSONNEL UNDRESSING AND MONITORING AT THE ZONE EXIT

Only one person at a time enters the exit airlock. The procedure below follows the go-forward principle. For greater efficiency and safety, undressing is carried out in supervised pairs from the same service. **The undressing supervisor must remain outside the vinyl sheet square throughout the undressing procedure.**



STEP 1 This step is normally carried out as a **2-person team**.

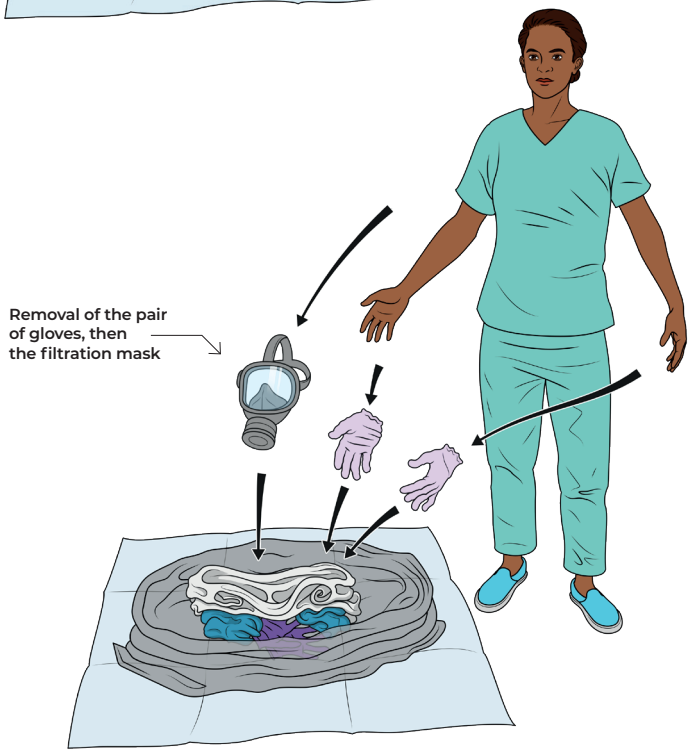
Position the person to be undressed in the centre of the 350-litre bin bag, which is rolled down at their feet, with the vinyl sheet under the bin bag. If the person is wearing a full-face mask with cartridge, a length of adhesive tape can be applied to the circumference of the cartridge (not on the air inlet).

Remove the pair of over-gloves and place them in the bottom of the bin bag.

Remove the coverall:

- open its zip;
- roll it down from the interior to the exterior ("rabbit skinning" method) starting with the head, then the torso, arms and legs;
- the entire coverall is rolled down to the feet inside the bin bag. Any contamination will remain trapped inside.

A small slit can be cut in the bottom of the coverall legs if it does not pass over the shoes (avoid forcing to avoid disseminating contamination).



STEP 2 This step can be carried out **without assistance**.

Leave the clean zone by stepping out of the bin bag.

Remove your under-gloves: place them in the bin bag.

Remove your filtration mask by its elastic straps, keeping it over the bin bag, taking care not to let the cartridge touch your chest. The elastic straps are clean because they were protected by the coverall hood.

STEP 3

This step requires the **assistance of another person**.

Close the bin bag, place identification on it and store it in a dedicated area at a distance from the airlock so as not to increase the background radiation value.

Check the undressed person using a detector capable of detecting low levels of alpha, beta and gamma contamination. If it is considered that once undressed, the person is "radiologically clean", this step may be omitted, which enables more people to be treated in a shorter time frame.

Check the level of contamination of the vinyl sheet. If it is positive: replace the sheet.

Optional checking of work clothing with a hand-held counter and ratemeter after removing PPE

Check of the vinyls sheet: if positive, replace it

Bin bag closed and taken away to the waste zone (far from the airlock)

STEP 4

This step is carried out by the **person alone**.

Record the active dosimeter results and name of wearer and place it in its dedicated storage location.

Once the PPE and coverall have been removed, remove the work clothes and **take a shower** if possible.

SHEET 23

ACTION TO TAKE ON THE SITE OF THE EVENT

Triaging the victims in the VAA

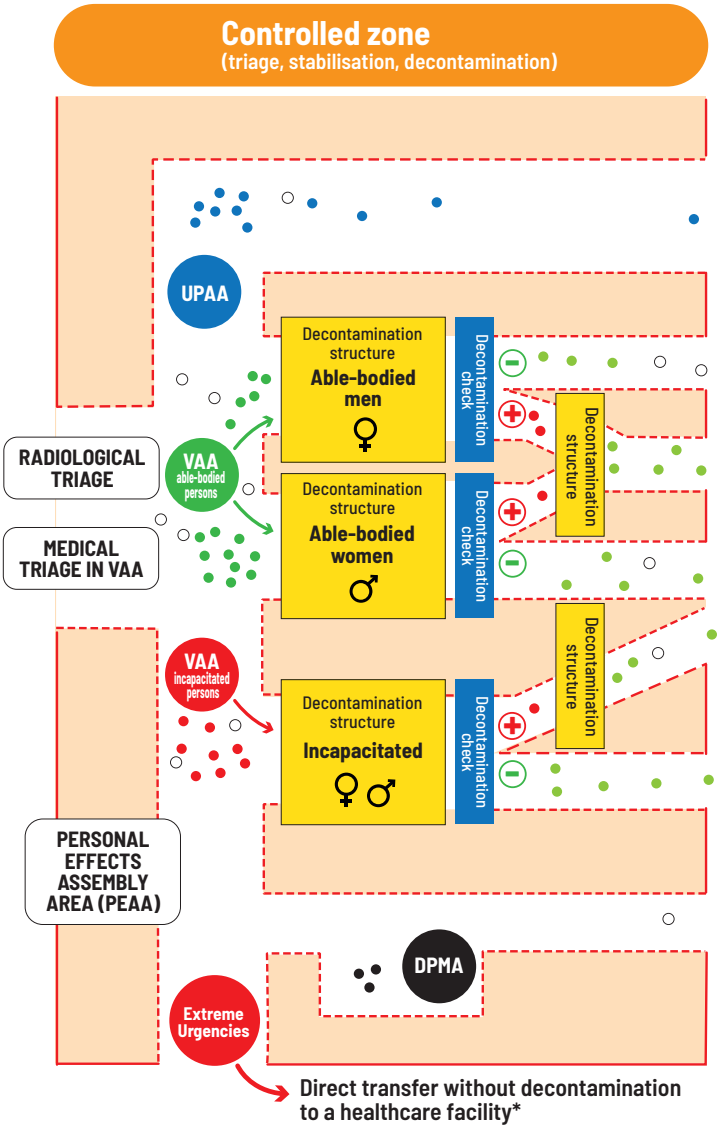
Responders
- Emergency medical teams: SMUR, RRHU

Places
Controlled zone

In the Victim Assembly Area (VAA), the victims receive all the necessary emergency treatments. If many people are involved, triaging is vital because the prioritisation of actions and treatments varies according to the categories of victims (contaminated, irradiated, contaminated and irradiated).

DIAGRAM No. 8

Medical and radiological triage



The VAA groups together:
- able-bodied and incapacitated injured victims,
- uninjured but contaminated victims,
- uninjured persons (able-bodied victims who are neither injured nor contaminated).

Triaging focuses first on the degree of urgency (medical criteria), then according to the level of contamination.

It serves to distinguish:
- the Absolute Urgencies (AU), including Extreme Urgencies (EU).
- the Relative Urgencies (RU).

In the case of an event involving a large number of victims, the prehospital medical structure consists of an Advanced Medical Post (AMP).

DPMA: Deceased Persons Management Area
PEAA: Personal Effects Assembly Area
UPAA: Uninjured Persons Assembly Area
VAA: Victim Assembly Area

- Uninjured victims without symptoms
- Able-bodied victims with symptoms
- Decontaminated victims
- Incapacitated victims with symptoms
- Deceased victims
- Medical team personnel

* After preparation of the victim and protection of the means of transport. SEE SHEET 20

SHEET 24

ACTION TO TAKE ON THE SITE OF THE EVENT

In the VAA: treating the absolute urgencies

Responders
- Emergency response teams: FRS
- Emergency medical teams: SMUR, RRHU

Places
Controlled zone

The Absolute Urgencies (AU) must receive medical-surgical treatment as rapidly as possible. In the Victim Assembly Area (VAA), they receive all the necessary emergency treatments. Decontamination operations can represent a loss of time and are not considered a priority. The Extreme Urgencies (EU) must be taken care of immediately and before any full decontamination procedures are applied.

Only the vital resuscitation actions are to be carried out before transporting the victims.

Emergency decontamination is carried concomitantly as soon as possible after stabilisation.

AU: perform emergency decontamination before evacuation

These victims have potentially severe injuries which limit full decontamination.
- Carry out the vital resuscitation actions before transporting the victims.
- Evacuate after emergency decontamination and appropriate preparation.

The injured victim can be transferred without further decontamination to the operating theatre or scanner of a healthcare facility. The additional decontamination shall be carried out after completing the emergency procedures.

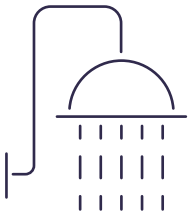
Decontamination must never hold back the treatment of an AU.

1 Emergency actions and emergency decontamination

- **Clean the face** with a damp compress.
- **Protect the upper airways** (to avoid transforming external contamination into internal contamination) and put in place an FFP3 or FFP2 mask or a surgical mask, in that order of preference.
- **If the contamination takes the form of dust, spray lightly with water** to avoid dispersing any dust deposited on clothing. **The skin must not be bare or be wet**, to avoid letting contamination of clothing lead to skin contamination. Particular attention must be paid to potentially contaminated run-offs.
- Whenever possible, **remove the outer layers of clothing** and put on a surgical cap. Undressing removes up to 90% of the external contamination: follow the same procedure as that applicable to 1st line healthcare facilities. **The procedure differs depending on whether the victims are standing or lying down.**

SEE SHEET 33

2 Full decontamination after completing the emergency procedures (non-aggressive showering)



- **Protect wounds** with a waterproof dressing.
- **Protect or move away items that are not water resistant** (remove them if possible).
- **Decontaminate the patients with soapy water**, using a showerhead if necessary for victims in the lying position.

Shaving is contraindicated because it causes micro-lesions of the skin.

EU: in principle, do not decontaminate before evacuation

These victims have injuries which require immediate medical care and possibly emergency surgery.

- Carry out the vital resuscitation actions before transporting the victims.
- Evacuate as is after preparation, without full decontamination.

In the event of emergency evacuation, **undressing must be carried out taking precautions** to avoid spreading any contamination.

- Decontaminate hands and face using a damp compress, to be used once only.
- Protect the upper airways with a surgical mask.
- Prepare the victim.

Proceed with medical evacuation to an appropriate healthcare facility after medical regulation.

SEE SHEET 20

PROTECTION OF THE MEDICAL TEAMS

The medical teams must be suitably protected until the absence of contamination is confirmed.

SEE SHEET 22

SHEET 25

ACTION TO TAKE ON THE SITE OF THE EVENT

In the VAA: decontaminating the relative urgencies

Responders
- Emergency response teams: FRS
- Emergency medical teams: SMUR, RRHU

Places
Controlled zone

The Relative Urgencies (RU) receive all the necessary emergency care at the Victim Assembly Area (VAA), concomitantly with emergency decontamination. Full decontamination is carried out in a second phase.

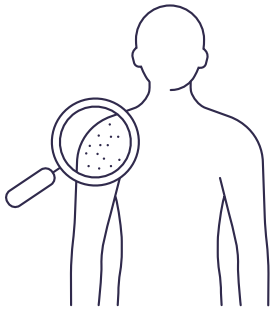
Always decontaminate.
3 to 4 steps to follow, depending on the case.

1 Emergency actions and emergency decontamination

- **Clean the face** with a damp compress.
- **Protect the upper airways** (to avoid transforming external contamination into internal contamination) and put in place an FFP3 or FFP2 mask or a surgical mask, in that order of preference.
- **If the contamination takes the form of dust, spray lightly with water** to avoid dispersing any dust deposited on clothing. **The skin must not be bare or be wet**, to avoid letting contamination of clothing lead to skin contamination. Particular attention must be paid to potentially contaminated run-offs.
- **Remove the outer layer of clothing**, which removes up to 90% of the external contamination: follow the same procedure as that applicable to 1st line healthcare facilities. **The procedure differs depending on whether the victims are standing or lying down.**

SEE SHEET 33

2 Detection (locating skin contamination)



Detection, even coarse, must be able to locate the skin contamination.

In the case of a large-scale event, detection cannot be carried out in the minutes immediately following its occurrence because it depends on the availability of the radiation protection equipment of the Mobile Radiological Response Units (MRRU) and the Emergency Medical Assistance Service (SAMU).

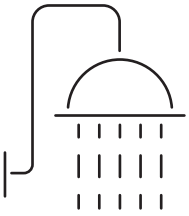
It must be done as soon as possible. When radioactive particles disperse in the atmosphere, the background radiation can be such that it risks rendering the detection uninterpretable. If such is the case, choose a new location for taking the measurements.

Use a detector equipped with a suitable probe for the type of radiation:
- X-ray probe in the majority of cases. All radionuclides except for pure β-emitters can be detected with an X-ray probe. The locating quality is excellent and the efficiency is satisfactory.
- If the radionuclide(s) is/are not known, the X-ray detection probe must be used first, then a beta-gamma probe and then an alpha probe.

If no means of detection are available, this step can be postponed.

SEE SHEET 32

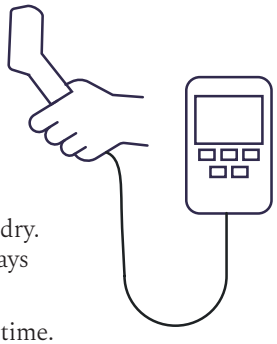
3 Full decontamination (non-aggressive showering)



- **Protect wounds** with a waterproof dressing.
- **Protect or move away items that are not water resistant** (remove them if possible).
- **Decontaminate the patients with soapy water**, using a showerhead if necessary for victims in the lying position.

Shaving is contraindicated because it causes micro-lesions of the skin.

4 Drying at the shower exit and radiation detection check



Circumstance and means permitting, it is recommended to conduct an additional radiation detection check.

After drying, check the decontaminated zones carefully with a detection probe that is appropriate for the type of radiation emitted by the contaminant.

Detecting alpha radiation is a very difficult and long process. The short path of alpha radiation requires the surface to be absolutely dry. Alpha emitters also emit X-rays or gamma rays whose detection is always easier and surer.

- **If the check is positive:** carry out decontamination (step 3) a second time.
- **If the second check is positive:** the contamination is considered to be fixed and there is no risk of contamination transfer.

SEE SHEET 32

SHEET 26

ACTION TO TAKE ON THE SITE OF THE EVENT

In the VAA: detecting external contamination of able-bodied persons

Responders
- Civil protection personnel (FB personnel from the FRS)

Places
Controlled zone

The able-bodied persons can be Relative Urgency (RU) victims who are on their feet, or uninjured persons.

1 Detect any external contamination

The contaminated uninjured persons and the RU victims are taken charge of in the Victim Assembly Area (VAA) for radiological triage.

CASE 1 — Contaminated injured but able-bodied walking RUs

First perform emergency decontamination, then fuller decontamination: shower before entering the Advanced Medical Post (AMP).

CASE 2 — Contaminated uninjured persons (UPAA)

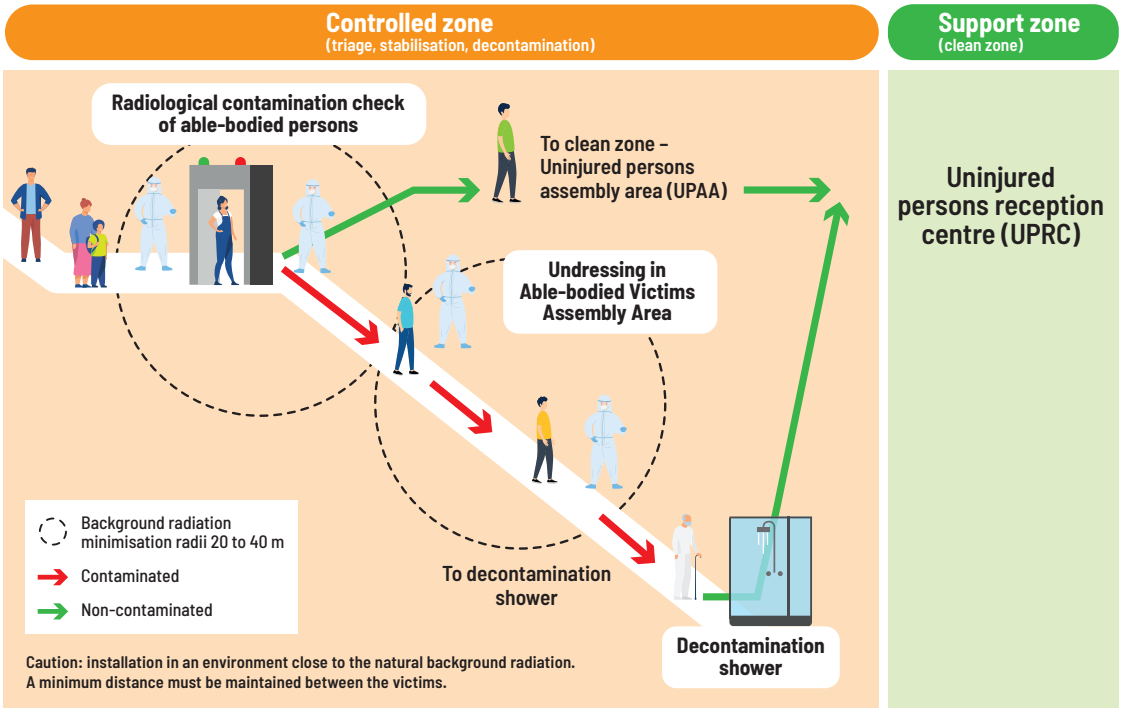
They follow the same route as case 1. First perform emergency decontamination, then fuller decontamination: shower before entering the Advanced Medical Post (AMP).

CASE 3 — Non-contaminated uninjured persons (UPAA)

They are directed to the Uninjured Persons Reception Centre (UPRC).

DIAGRAM No. 6

Triage of able-bodied persons by the portable radiological contamination portal monitor



2 Carry out emergency decontamination

- **Wipe the face**, with disposable wipes, for example.
- **Protect the upper airways**: FFP3 mask or FFP2 mask or a surgical mask, in that order of preference.
- **If the contamination takes the form of dust, spray lightly with water** to avoid dispersing any dust deposited on clothing. The skin must not be bare or be wet, to avoid letting contamination of clothing lead to skin contamination. Particular attention must be paid to potentially contaminated run-offs.
- **Undress the victim carefully**, removing the clothing layer by layer under the supervision of a fireman: victim standing on a vinyl sheet with a 350-litre bin bag rolled down at their feet.
SEE SHEET 33 *Standing victims*
- **Place the clothes in the sealed bin bag** as they are removed.
- **Place precious objects and identity papers in a transparent bag**, identified and secured, and affix a SINUS label to the bag after closing it. It shall be taken to the Personal Effects Assembly Area (PEAA): In the case of an act of terrorism, the personal effects are taken charge of by the Internal Security Forces in the PEAA.

3 Perform full decontamination (non-aggressive showering)

Take a short shower with soapy water. **Particular attention is required when washing hair:** wash the head leaning forward to avoid letting water run over the body. Take care not to contaminate the nostrils, ears or eyes.

4 Carry out a radiation detection check

This check is optional if the personnel and detection equipment resources are insufficient.

After drying: check the decontaminated zones carefully with a detection probe that is appropriate for the type of radiation emitted by the contaminant.

Detecting alpha radiation is a very difficult and long process. The short path of alpha radiation requires the drying to be perfect. The majority of alpha emitters also emit X-rays or gamma rays whose detection is always easier and surer.

SEE SHEET 32

5 If the radiation check is positive: carry out second decontamination

- **Carry out the second full decontamination**, focusing on the areas that are still contaminated (hair, for example).
- **Perform a decontamination check under the same conditions.** If this second check is positive, it is a case of fixed residual external contamination presenting no risk of dispersion. The victim can be taken to the AMP. The victim will subsequently undergo local decontamination by specialised teams.

IN PRACTICE

If there is no radiation portal monitor

Faced with "Chemical, Biological, Radiological, Nuclear" (CBRN) attacks, the resources are distributed uniformly by Civil Protection over the entire country (radiation portal monitors, mobile decontamination shower units, Mobile Radiological Response Units – MRRUs, etc.).

The time required to deploy the resources can vary depending on the site.

If there is no radiation portal monitor, all able-bodied people are considered to be potentially contaminated: carry out one emergency decontamination procedure and one full decontamination procedure, possibly followed by a contamination check depending on the local Civil Protection resources and/or reinforcements from the Institute of Radiation Protection and Nuclear Safety (IRSN).

SHEET 27

ACTION TO TAKE ON THE SITE OF THE EVENT

In the VAA: treating internal contamination and contaminated wounds

Responders
- **On nuclear site:** medical service
- **Off nuclear site:** emergency medical teams (FRS, RRHU, SAMU, SMUR)

Any person with suspected internal contamination must receive emergency treatment. The emergency treatment is applied *a priori*, unlike the long-term treatment, which must be determined according to the extent of the radioactivity incorporated.

Emergency treatment (as early as possible)

If possible, the treatment must be administered within two hours following contamination: as early as possible once the potential contaminating radionuclide(s) has/have been identified.

In the event of broad-spectrum contamination (mix of fission products), the recommended treatment comprises the following administered together: potassium iodide, Prussian Blue and Ca-DTPA.

Early administration is justified by the fact that this treatment has no habitual contraindications and it does not interfere with other treatments.

IRSN may be consulted for a specialised opinion at **call duty number:** +33 6 07 31 56 63 available 24h/24, 7d/7.

WHO ADMINISTERS THE TREATMENT?

PLACE OF TREATMENT	RESPONDERS	TREATMENT
If the accident occurs on a nuclear site	Site's medical service	The medical service has the appropriate antidotes for the radionuclides present on the site, as indicated in the radionuclide handbook.
Off the nuclear site in prehospital situation	Emergency Medical Assistance Service (SAMU) Emergency Medical and Resuscitation Service (SMUR)	Ca-DTPA, potassium iodide, Prussian Blue and Succimer (in the Mobile Medical Stations – MMS).
	Rapid Response Health Unit (RRHU) of the Fire and Rescue Service (FRS)	Ca-DTPA, Succimer and Prussian Blue (in the "VAA CBRN" kits).
Off nuclear site for hospital treatment	Regionally competent SAMU-Emergency call centre (15): it ensures the medical regulation to direct the patient(s) to the appropriate 1st line healthcare facilities which have the required treatment capabilities in addition to those implemented on the ground.	SEE SHEETS 38 to 40 + radionuclide handbook[10]

WHY ADMINISTER AN EMERGENCY TREATMENT?

When a radionuclide is incorporated in an organism, it irradiates the tissues for a time that varies according to the physical half-life of the radionuclide and its biological retention in the organs (this is the committed dose).

The therapy aims to speed up the natural elimination of the contaminant.
This reduces the quantity of radioactivity retained in the organism and hence the dose received by the tissues/organs and the risk of radiation-induced cancer.

10. It gives the recommended emergency treatments for the radionuclides concerned, with the radionuclides presented in alphabetical order.

Principal dose reduction mechanisms

INCREASE THE EXCRETION OF THE RADIONUCLIDE

Increase by **isotopic dilution** (*e.g.* tritium diluted by water), **mobilisation** (*e.g.* strontium mobilised by stable calcium), **blocking of storage** (*e.g.* radioactive iodine) or **chelation** (*e.g.* with plutonium).

CAUSE OF INTERNAL CONTAMINATION					TREATMENT
Tritium				T or ^{3}H Tritium	**Massive hydration** SEE radionuclide handbook (tritium)
Strontium		85 Sr Strontium	89 Sr Strontium	90 Sr Strontium	**Calcium salts** SEE radionuclide handbook (strontium)
Radioactive isotopes of iodine	123 I Iodine	125 I Iodine	131 I Iodine	132 I Iodine	**Potassium iodide: administer as early as possible.** The aim is to prevent the build-up of radioactive iodine in the thyroid, and the earlier the treatment the more effective it is. SEE SHEET 39 + radionuclide handbook (iodine)
Actinides (plutonium) and certain metals				240 Pu Plutonium	**Ca-DTPA, reference chelating agent, administered in 2 possible ways:** · by slow IV route: one half vial, *i.e.* 0.5 g without exceeding 1 g/day; · by nebulisation. SEE SHEET 39 + radionuclide handbook (plutonium)

REDUCE GASTRO-INTESTINAL OR PULMONARY ABSORPTION

CAUSE OF INTERNAL CONTAMINATION				TREATMENT
Radioactive caesium Indium Thallium	137 Cs Caesium	115m In Indium	201 Tl Thallium	**Prussian Blue, which chelates caesium,** forming a compound that is not absorbed in the digestive tract. It thus reduces the absorption of caesium and fosters its elimination in the stools. · Oral route: 3 g of Prussian Blue for adults SEE SHEET 39 + radionuclide handbook (caesium, indium, thallium)

Particular attention must be paid to children (and, by extension, to pregnant and breast-feeding women) because they are the most radiosensitive population group.

Treatment of wounds contaminated by actinides and certain metals

This technique uses the chelating power of Ca-DTPA with respect to actinides and certain metals.

1. Wash the contaminated wounds for draining, using vials of injectable Ca-DTPA.
2. Cover the wound with an absorbent dressing containing 3 to 4 g of Ca-DTPA (injectable vials – 25% solution).

SEE SHEET 39

IF NOT TREATED IN VAA

If contaminated wounds have not been treated in the Victim Assembly Area (VAA), they are treated in the 1st line healthcare facility.

SHEET 28

ACTION TO TAKE ON THE SITE OF THE EVENT

At the AMP: managing the victims

Responders
- Medical teams: physicians and paramedical personnel
- Pharmaceutical teams
- Emergency response teams: FRS, rescue workers from approved civil protection associations
- Emergency medical teams: SMUR, RRHU

Places

Support zone

The Advanced Medical Post (AMP) is the core structure of the prehospital medical chain in events involving large numbers of victims. It is situated downstream of decontamination: in the support zone, in an existing building or a temporary structure (tent).

At the AMP entrance: attach the SINUS bracelet and conduct another medical triage

The triage on entering the AMP serves to reassess the seriousness of the condition of the victims. Depending on their condition and the chosen place of hospitalisation, the victims will not necessarily stay at the AMP.

- **Binary triage:** Absolute Urgencies (AU) / Relative Urgencies (RU).

Transfer of victims from the UPRC to the AMP

Whenever possible, the Uninjured Persons Reception Centre (UPRC) is situated near the AMP. Any person whose medical condition deteriorates very suddenly is immediately transferred to the AMP or to an identified healthcare facility after medical regulation by the SAMU.

Deliver the necessary medical care

Alongside the regulation work, **at the AMP each victim receives the necessary medical care according to their condition**, pending their transfer to the most suitable healthcare facility.

The radiological context must not alter the stabilisation of the victims by the Mobile Emergency and Resuscitation Service (SMUR) and the Rapid Response Health Unit (RRHU).

The AMP has radionuclide antidotes and chelating agents.

The equipment at the AMP can be backed up by the means from the Mobile Medical Station (MMS) I or II and the paediatric MMS if necessary.

When victims do not require any additional care before being transported, and a means of transport is available immediately, they will spend little time, if any, at the AMP.

Ensure medical regulation

Medical regulation ensured by the regionally competent Emergency Medical Assistance Service (SAMU) determines the priorities for victim transportation and the choice of place of hospitalisation.

Ensure the protection of the personnel

The personnel in contact with victims who have been decontaminated (full decontamination) and checked wear their usual working garments. SEE SHEET 22

If full decontamination has not been carried out, it is recommended that the personnel should always wear:
- overblouse,
- FFP3 mask or, failing this, FFP2,
- two pairs of gloves.

PROTECT IRRADIATED VICTIMS WITH NO EXTERNAL CONTAMINATION

Heavily irradiated victims, confirmed as being free of external contamination, can suffer are reduction in their immune response. The must be protected against the risk of infection.

It is vital for the personnel to continue wearing protective garments: overblouse, surgical mask and two pairs of gloves.

SHEET 29

ACTION TO TAKE IN A 1ST LINE HEALTHCARE FACILITY

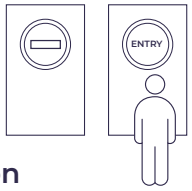
Preparing the premises, rehabilitating them and managing the waste

Responders
- Healthcare facility personnel and radiation protection experts

The transfer to a healthcare facility, reception and treatment of the victims of a radiological or nuclear (RN) accident can lead to the transfer of radioactive contamination to the personnel and the infrastructure of the facility, and to the production of radioactive waste. Such a situation is severely aggravated if there is a massive and more or less well controlled influx of victims, including non-decontaminated victims. The 1st line healthcare facilities must prepare themselves to cope with such situations.

The 1st line healthcare facilities have a structured full decontamination capability. They are capable of ensuring the medical care of a non-decontaminated Extreme Urgency (EU) patient.

Preparing for the reception of victims



1 Set up an SI-VIC secretariat

- **At the entrance to the area dedicated to the external reception of victims.** For self-presenting non-decontaminated persons, this reception area may be situated before the Hospital Decontamination Unit (HDU).
- **This secretariat enters the relevant information in the victim tracking information system** (SI-VIC) and in the Hospital Information System (HIS).

2 Reserve a room for reception and undressing

- **Room with separate entry and exit doors to establish a direction of movement.**
- **Room that is easy to decontaminate:** the floor and if possible the walls are covered with vinyl sheeting; as many of the fittings as possible (radiators, pipes, etc.) are protected with vinyl sheeting.

Example:
The ambulance reception area or the accident & emergency waiting room could be assigned to this function.

If a different entrance to the conventional A & E entrance can be used, that entrance shall be used in priority.

3 Set up a route for non-contaminated victims

- The non-contaminated victims (after being checked) must not pass through a "dirty" zone.
- **A specially fitted out corridor provides direct access to the "clean" treatment zone.**

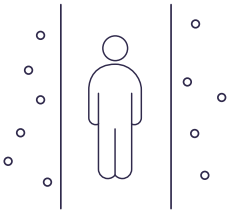
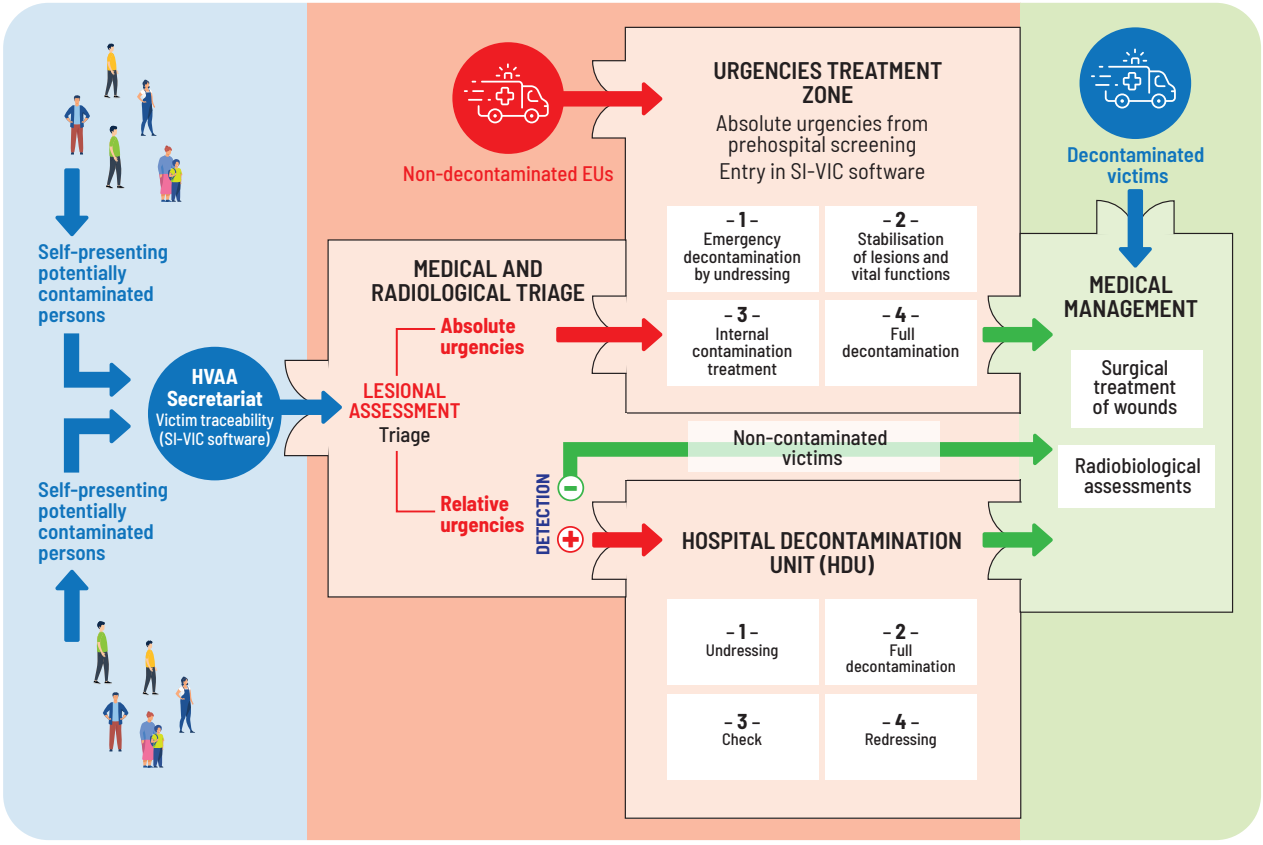


DIAGRAM No 5

Ideal model of a reception setup in a 1st line healthcare facility *(general diagram)*



HVAA: Hospital Victim Assembly Area

After medical and radiological triage, the contaminated victims are treated in two separate zones:

- decontamination of relative urgencies (in HDU),
- treatment of Absolute Urgencies (AU).

Prerequisite:

The reception zone (Hospital Victim Assembly Area – HVAA) is situated before the entrance to the healthcare facility.

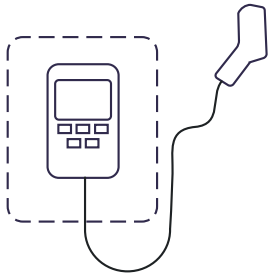
The circuit is organised in accordance with the go-forward principle: back-tracking is impossible (in principle). The **"go-forward" principle** applies to the two broad categories of urgencies identified after triage: Relative Urgencies (RU) and Absolute Urgencies (AU).

Each zone has a system for collecting contaminated waste (vinyl bags) and, insofar as possible, a system for collecting contaminated water.

The traceability of the patient's personal effects is ensured.

If there is a massive influx of victims, the healthcare facilities must adapt, on the basis of this model, according to their architecture and their organisation (see "Chemical, Radiological, Nuclear" – CRN section of the Plan for managing hospital resource shortages and exceptional public health situations – "White plan").

4 Provide and protect the reception zone equipment

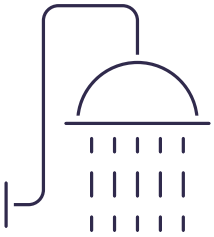


The equipment is limited to the indispensable mobile appliances.

Protection of the equipment:

- **mobile appliances:** protection by vinyl sheeting can be considered;
- **medical and radiation protection equipment:** protect as much as possible with food-grade plastic film (except for the sensors of the radiological detection devices, if alpha emitters are present).

5 Assign a zone to decontamination

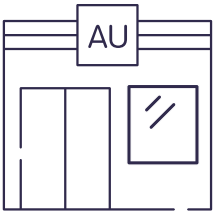


The actions of contamination detection, decontamination and checking decontamination must be geographically separated.

- Zone adjacent or close to the reception zone (medical and radiological triage).
- Zone compatible in all circumstances with a rapid medical intervention (secondary aggravation of a victim).
- Zone equipped with a hose-mounted shower system for the decontamination of victims and subsequently the personnel.
- Floor with a surface covering that can be readily decontaminated (avoid tiled floors because of the grouted joints).
- Protection of the zone: cover the floor and walls with vinyl sheeting, particularly in the sections with complex geometries or crevices (radiators, visible pipes).
- Collection of contaminated water: it is preferable to be able to recover the contaminated water, even if this necessitates having a temporary collection system. In some situations it is impossible to collect the water, in which case the effluents must be diluted as much as possible during discharging. If contaminated water is discharged into the wastewater network, the wastewater treatment plant manager must be informed.

Decontamination of AUs: full decontamination is carried out after stabilising the life-threatening lesions.

6 Assign a zone to the treatment of AUs who have not undergone full decontamination and to the surgical treatment of wounds



- **A zone dedicated to the treatment of AUs is identified and separated from the conventional urgencies treatment pathway.** The medical management of these contaminated victims makes it necessary to protect the premises and the equipment (vinyl sheets) at least to the extent detailed in points 4 and 5. This sector can be materialised by folding screens or movable partitions.
- People who have undergone full decontamination but have wounds shall receive medical care in a zone dedicated to the surgical treatment of these wounds, with suitable precautions taken for the personnel.

Rehabilitating the premises

Contamination management with a view to rehabilitating the premises differs little from the usual maintenance and cleaning operations.

It nevertheless has a few particularities:

- wear appropriate Personal Protective Equipment (PPE) SEE SHEET 6;
- favour specific detergents: with a surfactant activity and sequestering agents commonly used in "hot" laboratories and nuclear medicine departments (TFD decontaminating foam spray, etc.). If not available, use standard detergents;
- work at least in pairs and coordinate your actions: one person carries out the decontamination while limiting their movements to avoid dispersing the contamination, while the other person(s) provide(s) support;
- determine the boundaries of the contaminated areas (radioactive contaminations on surfaces such as tables or floors are rarely uniform): use high-sensitivity detectors (narrow window and, if possible, wide window, such as a contamination meter or X-ray probe), protected with food-grade plastic film;
- decontaminate (with disposable wipes, or possibly paper towel), starting from the outer edge of the contamination stain and working inwards to limit contamination dispersion;
- to remove all possible traces of residual contamination: perform a 2nd decontamination step (or a 3rd one depending on the results of the measurements) over the whole surface. For example, the entire floor of a room. **Vacuum cleaners should not be used because they generate aerosols;**
- decontaminate the material and equipment in the usual manner, but working over a receptacle if possible, without making sudden movements.

All the decontamination waste products (washing water and materials) are in principle regarded as radioactive waste.

IN PRACTICE

Declare rehabilitation of the premises

The absence of residual contamination must be confirmed by an entity with the appropriate skills and means.

- Internal Radiation Protection Service (RPS),
- RPS of a neighbouring facility providing back-up assistance,
- Inter-facility Radiation Protection Organisation,
- or the Radiological Intervention and Environmental Monitoring Service (SIRSE) of the Institute of Radiation Protection and Nuclear Safety (IRSN) – irsn.sirse@irsn.fr.

Manage the waste

The radioactive waste comes from the potentially contaminated victims and from contamination management.
The waste can be liquid (washing water, etc.) or solid: vinyl bags, clothing, used PPE, decontamination products, etc. The volume of the waste depends on the nature and scale of the event. The traceability and management of radioactive waste must be organised according to its radiological characterisation.

Healthcare facilities that do not have a nuclear medicine department can request assistance from the nuclear medicine department of the Regional Reference Hospital for the RN risk – RRH RN (see pages 138-139).

1 Perform radiological characterisation (nature of the radionuclides present)

This characterisation makes it possible to indicate whether on-site radioactive decay management is possible or not.

If radioactive decay cannot be ensured internally, consult the crisis management centre; it should be able to provide solutions.

2 Collect the radioactive waste

The radioactive waste must be collected in the containers provided by Andra, the French radioactive waste management agency, particularly waste with a half-life exceeding 100 days.
These containers are usually present on site if activities involving unsealed sources are conducted in the facility. **If not available, use:**

- **recipients such as empty canisters** (having contained detergents, for example) to collect the effluents;
- **containers provided for Infections Clinical Waste** (ICW) to collect the solid waste.

3 Store the waste

A room dedicated to the management of radioactive waste in compliance with the regulations must be used if the facility has one (waste storage bunker of the nuclear medicine department for example).

If there is no dedicated room, whenever possible use a room with the following characteristics:

Mandatory characteristics

- Isolated and secure room (with access control and at least a lock). If necessary, the Radiation Protection Expert (RPE) will delimit zones and put in place the appropriate signs.
- Forced mechanical ventilation (the presence of High-Efficiency Particulate Air (HEPA) filters is an added advantage).
- Readily decontaminated floor (epoxy resin or plastic covering), with the finish rising up at the plinths.
- Fire safety systems.
- Receptacle trays for storing the liquid effluent containers.

Other characteristics

- Washable paints on the walls, lighting complying with ATEX (Explosive Atmosphere standards).

The public authorities, in collaboration with the Prefect and the Regional Health Agency, shall specify what is to become of this waste: grouping on a specially created storage site or transfer to an existing disposal facility.

SEE SHEET 10

IN PRACTICE

Managing the excreta of victims with internal contamination in a hospital

Apart from the first excreta collected and managed as samples for radiotoxicological analysis to evaluate the internal dose SEE SHEETS 37 38, these excreta are managed as follows:

- **only the urines that could present a radiation protection risk are collected** and directed to the usual drainage routes for hospitals with a nuclear medicine department (by analogy with the urines of patients who have been administered radiopharmaceuticals);
- **in facilities that do not have a nuclear medicine department**, the urines can be collected in sealed recipients (such as empty 20-litre detergent canisters, etc.) and stored in a room dedicated to the management of radioactive waste and effluents (see opposite) pending transfer to a disposal route appropriate for the radiological content.

In the exceptional case of a victim suffering internal contamination by ingestion and by alpha-emitting radionuclides, the stools can be collected in suitable containers and managed in the same way as the urines.

SHEET 30

ACTION TO TAKE IN A 1ST LINE HEALTHCARE FACILITY

Protecting the healthcare facility personnel

Responders
- Personnel of the RRH RN and the other 1st line healthcare facilities
- Radiation protection experts

The personnel must be protected. This sheet details the personal protective equipment and gives practical advice to facilitate personnel dressing and undressing.

The protective equipment

IF THE VICTIMS HAVE UNDERGONE FULL DECONTAMINATION

INTERVENTION CONTEXT	EQUIPMENT
Contact with previously decontaminated victims (full decontamination in the field)	**Usual work clothes.** **Gloves and surgical mask recommended** (the risks of contamination and irradiation are inexistent or very low).
Surgical treatment of Relative Urgencies (RU) after full decontamination	**Usual work clothes** (the risk of contamination of the personnel and the facilities is very low). **All the responders must be listed** and be subject to specific follow-up by the occupational health service.

IF THE VICTIMS HAVE NOT UNDERGONE FULL DECONTAMINATION

INTERVENTION CONTEXT	EQUIPMENT
Intervention at the Hospital Victim Assembly Area (HVAA) after confirmation that there is no chemical contamination **Intervention with individual victims given medical care and not decontaminated in the field**	**Protective clothing and Personal Protective Equipment (PPE) for all the personnel:** non-woven coverall, FFP3 mask or, failing this, FFP2 mask, surgical cap, safety glasses, overshoes or overboots.
Absolute Urgency (AU) treatment zone (admission after undressing)	**The personnel must wear PPE:** non-woven coverall, FFP3 mask or, failing this, FFP2 mask, surgical cap, safety glasses overshoes or overboots (the risk of contamination of the personnel and facilities is low but not zero).
Intervention in the Hospital Decontamination Unit (HDU) receiving the RUs	**Decontamination clothing and PPE for chemical risks** (impermeable light decontamination coverall, mask with multipurpose cartridge). **The non-woven coverall and FFP3 mask cannot be used** because spattering and vapour would saturate the FFP3 mask.
Operating theatre before full decontamination for the AUs	Appropriate protective garments (PPE) for the operating theatre: • **for the theatre nurses and the anaesthesia team**: non-woven garment type 5-6, overboots and FFP3 mask or, failing this, FFP2 mask; • **for the surgical team:** surgical clothing with reinforced protection (orthopaedic s gown), overboots and FFP3 mask or, failing this, FFP2 mask, safety glasses; • **if possible use long-sleeved surgical gloves** (used in obstetrics department), double pair of gloves.

SEE SHEET 6

Practical advice for preparing personnel dressing and undressing

Prior training, drills and regular practice sessions are necessary.

- **Before the casualty arrives:** give a brief reminder of the technique.
- **Organise the dressing place:** prefer spacious rooms.
- **Call upon people with experience in the procedure to supervise this stage.** For example: "Chemical, Biological, Radiological, Nuclear" (CBRN) advisors, members of the CBRN mission for significant radiation protection events, Radiation Protection Experts (RPE).
- **Use stockinette to protect hair** (adapt the size to suit the length of hair) or use a surgical cap or the hood of a coverall.
- **Identify the medical personnel using electrician's insulating tape** in the identification colours of the hospital gowns.
- **Prepare individual kits** for the medical personnel comprising the following PPE:
  - bags for personal effects: pager, telephone,
  - stockinette for hair or surgical cap or coverall hood,
  - overboots,
  - gloves,
  - non-woven garment type 5-6,
  - second pair of gloves,
  - identification,
  - mask.
- **Equip the medical personnel with dosimeters.**

SEE SHEET 16

IN PRACTICE

Self-undressing technique *(photos taken during a practical intervention training session in the VAA in non-woven garment type 5-6)*

Consider supervision in pairs (behind a glass window for example).
To avoid transfer of contamination:

- **Protect the undressing zone with vinyl sheet.**
- **Undress standing over a 350-litre bin bag** in which the waste materials will be collected (the bag will be closed by the following person who is still dressed).
- **Open the zip completely.**
- **Remove the coverall hood**, turning it inside out while keeping the hands on the outside.
- **Free the shoulders** (always keep the hands on the outside of the coverall).
- **Take the fingers out of the gloves.**
- **Peel down the coverall** (turning it inside out), keeping outer surface against outer surface to avoid dispersing any contamination (the glover remain attached).
- **Tie the sleeves** in front of the waist.
- **Step out of the coverall, touching its interior surface only.**
- **Lastly, remove the mask.**
- **Read the active dosimeter** (readings recorded with the healthcare facility's occupational medicine service).



SHEET 31

ACTION TO TAKE IN A 1ST LINE HEALTHCARE FACILITY

Receiving and managing the victims

Responders

- Personnel of the RRH RN and the other 1st line healthcare facilities
- Radiation protection experts

The victims are admitted into the reception, medical and radiological triage zone. This zone is dedicated to triaging the casualties, conducting a brief medical examination and limited resuscitation. It could become contaminated. The victims are then directed to an appropriate medical care pathway.

Medical-surgical urgencies take priority over contamination and irradiation.

The decontamination zone is potentially the most contaminated zone. Contacts between victims must be minimized to avoid any transfer of contamination to non-contaminated victims and to reduce the risks of contaminating the personnel.

90% of the contamination can be removed by undressing. This operation is very important.

Hospital care in the 1st line healthcare facilities

The hospital care concerns more specifically the Regional Reference Hospitals for the Radiological and Nuclear risk (RRH RN).

STEP 1 **As soon as the alert is given, get the personnel ready to receive the victims** (who self-present, potentially not triaged and not decontaminated, or are sent after regulation by the Emergency Medical Assistance Service – SAMU): under the Plan for managing hospital resource shortages and exceptional public health situations ("Chemical, Radiological, Nuclear" – CRN section, and if there is a massive influx of victims, the "Massive reception of victims" – AMAVI section) by activating the level 2 "White plan".

STEP 2 **For the RRH RNs: treat the specific non-decontaminated Extreme Urgency (EU) cases**, which could arrive exceptionally in small numbers after medical regulation.

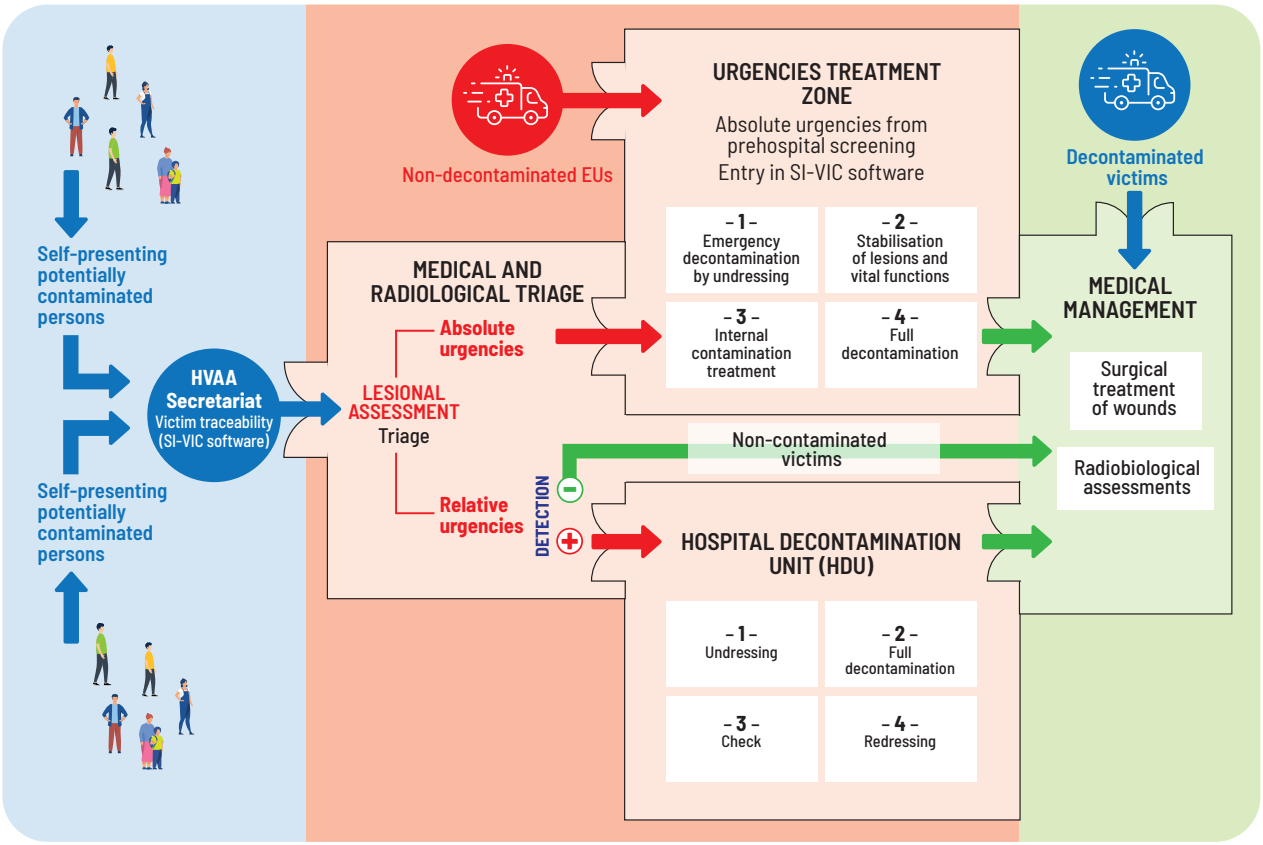
STEP 3 **Protect the personnel and the structure against contamination transfer:** the appropriate measures must have been taken to protect the personal and the infrastructure against the transfer of contamination and to ensure the emergency decontamination of the victims.

STEP 4 **Carry out emergency decontamination, then full decontamination.**

Healthcare facility admission and treatment protocols

DIAGRAM No 5

↳ **Ideal model of a reception setup in a 1st line healthcare facility** *(general diagram)*



HVAA: Hospital Victim Assembly Area

RECEPTION ZONE

PERFORM MEDICAL TRIAGING: ABSOLUTE URGENCIES (AU), RELATIVE URGENCIES (RU)

1. Direct the AUs to a dedicated zone without prior full decontamination.
2. Direct the non-decontaminated RUs to a Hospital Decontamination Unit (HDU) for full decontamination.
3. Carry out the lesional assessment of the victims: to be carried out by the physician who triages the victims, so that this zone never becomes overcrowded.

ABSOLUTE URGENCIES TREATMENT ZONE

TREAT THE AUs IMMEDIATELY WITHOUT PRIOR RADIOLOGICAL MONITORING

1. Undress the victims to ensure emergency decontamination. Identify and conserve the personnel effects and clothing in case there is a subsequent investigation.
2. Protect the personnel SEE SHEET 30 and the examination tables or beds with vinyl sheeting.
3. Transfer the victims to the zone for treating urgencies (**the medical urgency takes priority over the radiological risk**).

i In addition to the usual personnel of an emergency department, **one or two people from the RRH NRs must be brought into this zone as soon as possible**. They are capable of using the contamination detection devices.

4. Carry out the life-saving actions.
5. Apply without fail the contamination detection and localisation protocol.

Case of low-level external contamination: carry out a cursory decontamination using compresses soaked in liquid soap or a 25% solution of Ca-DTPA. This decontamination is incomplete but remains effective.

6. After stabilising the lesions and vital functions, carry out full decontamination.

HOSPITAL DECONTAMINATION UNIT: RELATIVE URGENCIES

1. Carry out radiological triaging of the RUs (detection of external contamination): before entering the hospital full decontamination zone.
2. Carry out a radiological contamination check on the victims. For the triage to be effective, this check must be check must be done with method and rigour. This triage serves to prevent the decontamination zone from becoming congested with non-contaminated victims.

If there is no radiation monitoring portal, detection is done using radiation survey meters equipped with alpha – beta probes or hand-held multi-radiation (alpha – beta – gamma) count rate meters. Nevertheless, if there are many victims, they will all go through full decontamination.

SEE SHEET 32

Non-contaminated victim: route the victim directly to the emergency department without passing via the decontamination zone.

Contaminated victim: route the victim to the Hospital Decontamination Unit (HDU) and carry out emergency decontamination followed by full decontamination.

EMERGENCY DECONTAMINATION

3. Protect the upper airways. SEE SHEET 20
4. Proceed with undressing. The technique differs depending on whether the victim is lying down or standing. SEE SHEET 33
5. After decontamination: the physician details the lesional assessment of the victim indicating any necessary complementary examinations.
6. If the victim is in a protective bag, the table or examination bed can be covered with a vinyl sheet that extends well down on each side.

FULL DECONTAMINATION

This supplements the emergency decontamination (to remove any traces of residual contamination), in order to prevent the transfer of contamination within the facility (to patients, hospital personnel or infrastructure).

MEDICAL MANAGEMENT ZONE

CONTAMINATED WOUND TREATMENT PROTOCOL

The victims are admitted after undressing and decontamination. **The lesions can be treated anywhere in the healthcare facility** (very low risk of contamination).

1. In the case of contamination by actinides, immediately pour a 25% solution of Ca-DTPA (undiluted injectable vials): over any wound or burn to minimise the retention of radionuclides.
2. Trim the wound: to be carried out by a surgeon, if possible in the presence of a person specialised in the detection of radioactivity as this is vital to evaluate the level of decontamination of the wound.
3. If careful trimming has not resulted in total decontamination or if it is not known whether total decontamination has been achieved: **establish a complementary. internal decorporating treatment specific to the radionuclide**, because the wound is not completely closed up to allow decontamination.
4. Determine the treatment follow-up on a case-by-case basis, taking into account:
   - the radionuclide(s) involved;
   - the severity of the local residual contamination;
   - the risks of diffusion of the radioactivity;
   - the anatomical location;
   - the possibilities or difficulties of surgical treatment.

No damaging surgical act is justified in an urgent situation for the purpose of decontaminating a contaminated wound.

EARLY TREATMENT OF INTERNAL CONTAMINATION

If it has not already been done, early treatment of the internal contamination must be undertaken.
SEE SHEET 27

The Radionuclide Handbook contains the recommended emergency treatments for the radionuclides of interest, with the radionuclides indicated in alphabetical order. SEE radionuclides handbook

PERSONNEL DRESSING AND UNDRESSING SEE SHEET 30

SHEET 32

ACTION TO TAKE IN A 1ST LINE HEALTHCARE FACILITY

Detecting external contamination

Responders

- Radiation protection expert or other personnel trained in radiation detection

The method of detection differs depending on whether the radionuclides responsible for the potential external contamination are known or not. This contamination monitoring task is of vital importance to determine the medical pathway of the victims.

© Mirion Technologies

© Ludlums Measurements, Inc.

Examples of count rate meters

CASE 1

The type of radiation emitted is not identified.

Use a hand-held detector: multi-radiation (alpha, beta, gamma) count rate meter of the narrow-window Geiger-Muller type.

This type of detector risks measuring the internal gamma radiation as well.

© Berthold Technologies

© APVL ingénierie

© Tracerco

Examples of radiation survey meters

CASE 2

The contaminating radionuclides are known.

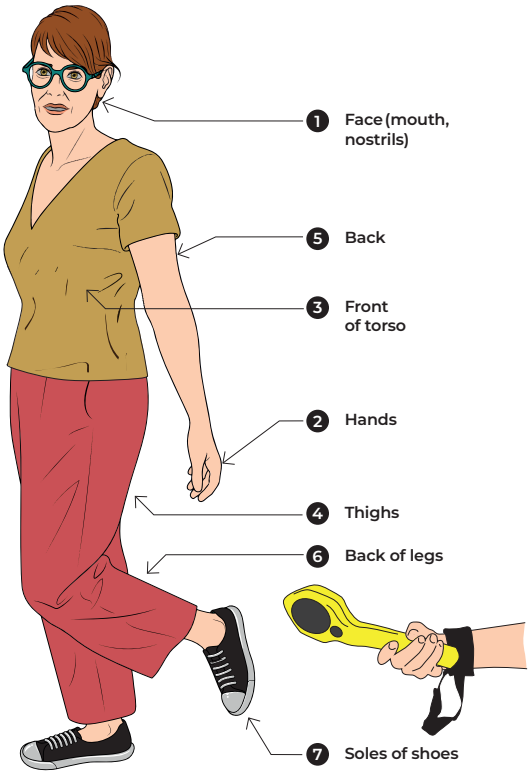
They present sufficiently high levels of alpha or beta radiation to be detectable.

Perform detection using radiation survey meters equipped with alpha and beta probes or one combined alpha – beta probe to avoid measuring any internal gamma contamination.

Detection must be carried out in a very meticulous and repetitive manner.

- Protect the probe or count rate meter with food-grade film, except for the sensor.
- Do not let the probe come into contact with the clothes or the victim to avoid contaminating it, but bring it sufficiently close (about 1 cm from the surface) to detect the alpha radiation.
- Measure the external contamination by a check at slow speed of about 1 cm/s, to allow for the detector response time, especially when the level of contamination is low and alpha emitters may be present.

PROCEDURE FOR CHECKING VICTIM CONTAMINATION



Check that the detector is functioning properly and note the value of the background radiation. Know the utilisation limits of your detector.

Protect the detectors except for the windows for alpha emissions.

Check the victims

- Slow speed 1 cm/s and at a distance of 1 cm from the skin and clothes. The operator performing the check stands as far away as possible (arm's length) to limit their own exposure.
- Start with the face ❶ (mouth, nostrils), the hands ❷, front of torso ❸, thighs ❹, back ❺, back of legs ❻, soles of shoes ❼.
- **Start with the face**, checking very carefully around the mouth and nostrils, then the hands (first the palm, then the back of the hand). If the face contamination check is positive, have the victim blow their nose then place a surgical mask on their face. Put the handkerchief into a bag marked with the name of the victim.
- **Check the rest of the body from top to bottom** starting with the front, then the back. If the victim's hands are found to be contaminated, put a pair of nitrile gloves on them.
- **Finish the check with the soles of the shoes.** If the shoe contamination check is positive, put on a pair of overshoes.

EXTERNAL CONTAMINATION

Contamination is considered positive when the detected value is more than twice the background radiation of the detector.

If the check is negative (no traces of external contamination): leave the zone by the "clean" corridor

- **Direct the victims to the mobile whole body radiation measurement and/or portable spectrometry means to check the internal contamination and/or collect excreta, depending on the radionuclides involved.**
- If the means are not available on site, the victim may be asked to undergo a whole body radiation measurement in mobile or fixed facilities and/or collection of excreta at a later date, depending on the radionuclides involved. SEE SHEET 37

If the check is positive (external contamination detected): direct the victim to the decontamination zone

- Undress, using the "peeling off" technique. SEE SHEET 33
- Carry out full decontamination.
- Dress in hospital pyjamas or gown or scrub suit. SEE SHEET 33

After full decontamination, if the victim has no external body contamination, direct them to the internal contamination measurement and/or excreta collection means, depending on the radionuclides involved.

PERSONNEL IN CHARGE OF THE DECONTAMINATION CHECK	PERSONAL PROTECTIVE EQUIPMENT
Hourly rotation of personnel with 30-minute break (physiological constraints linked to the PPE, repetitiveness of the checking tasks). *Tiredness reduces the precision of the gestures and can result in detection errors.*	· Paper coverall type type 5-6 with hood. · Paper overboots. · Nitrile gloves (two pairs). · Safety glasses and FFP3 mask or, failing this, an FFP2 mask. · Passive dosimeter and active dosimeter.

SHEET 33

ACTION TO TAKE IN A 1ST LINE HEALTHCARE FACILITY

Undressing the victims

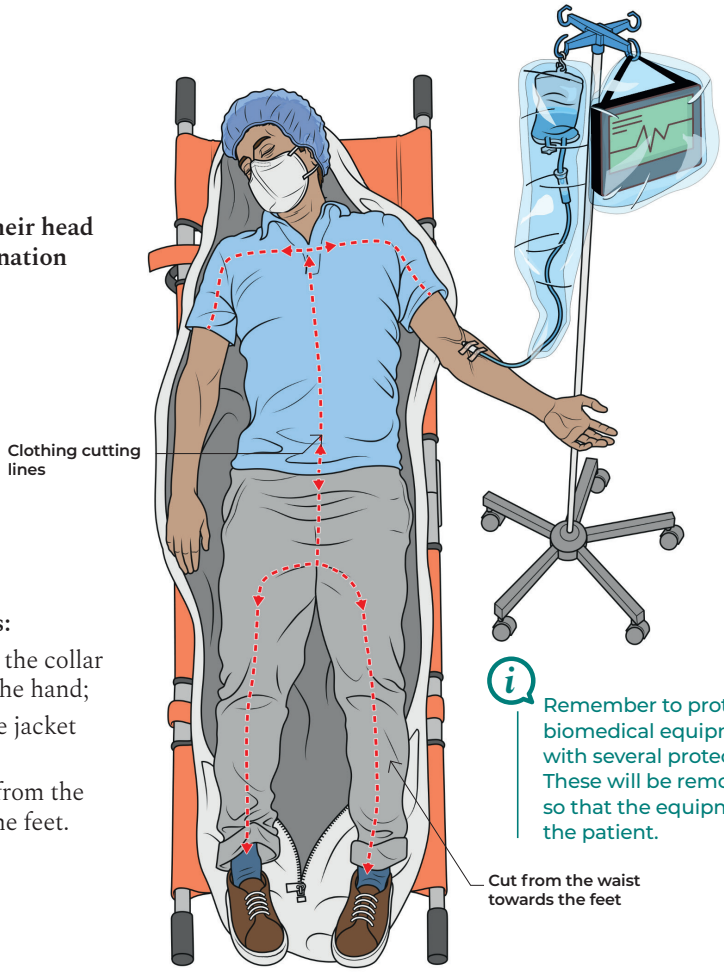
Responders
- Hospital decontamination teams

Undressing is a very important operation as it removes up to 90% of the external contamination. It is important to bear in mind that long hair can retain a lot of contamination and is difficult to decontaminate completely.

UNDRESSING DIAGRAM FOR STRETCHER VICTIMS

1. Open the bag in which the victim is placed.

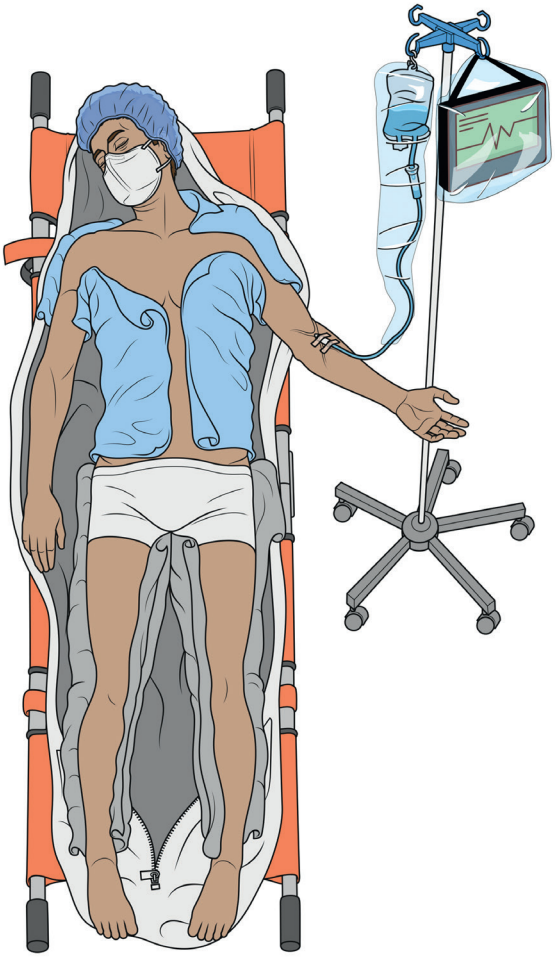
2. Put a surgical cap on their head to confine the contamination of the scalp.



3. Cut the victim's clothes:
- at the sleeves: start from the collar (neck) working towards the hand;
- at the front closure of the jacket or coverall;
- at the trouser legs: start from the waist working towards the feet.

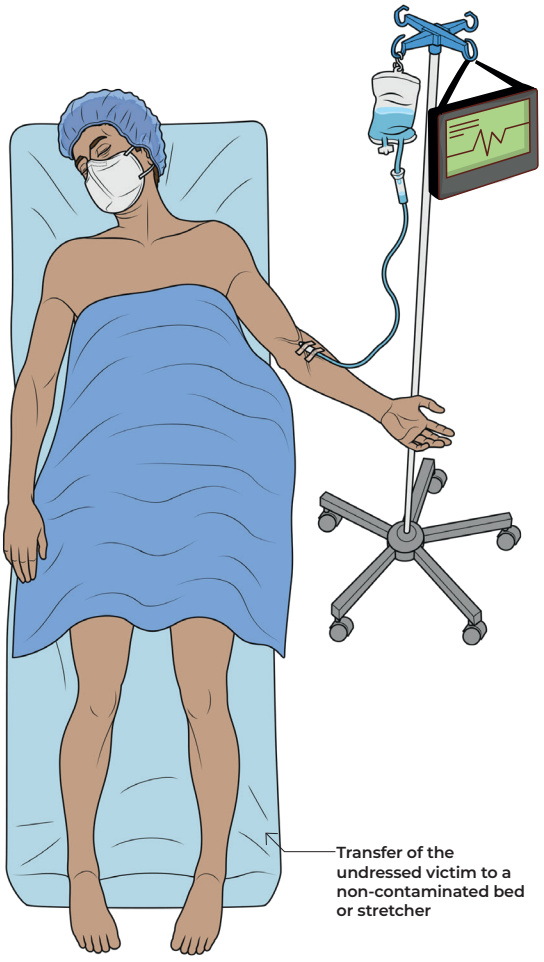
Remember to protect the biomedical equipment (scope) with several protective layers. These will be removed successively so that the equipment can follow the patient.

4. **As cutting proceeds, roll the clothes over themselves,** turning them inside out. The contamination deposited on the surface of the clothes is thus confined.



5. **Lift the victim (stretcher bearers) and place them on another** or put them back on the same stretcher once the personnel who cut away the clothing has removed the bag or vinyl sheet containing the contaminated clothes.

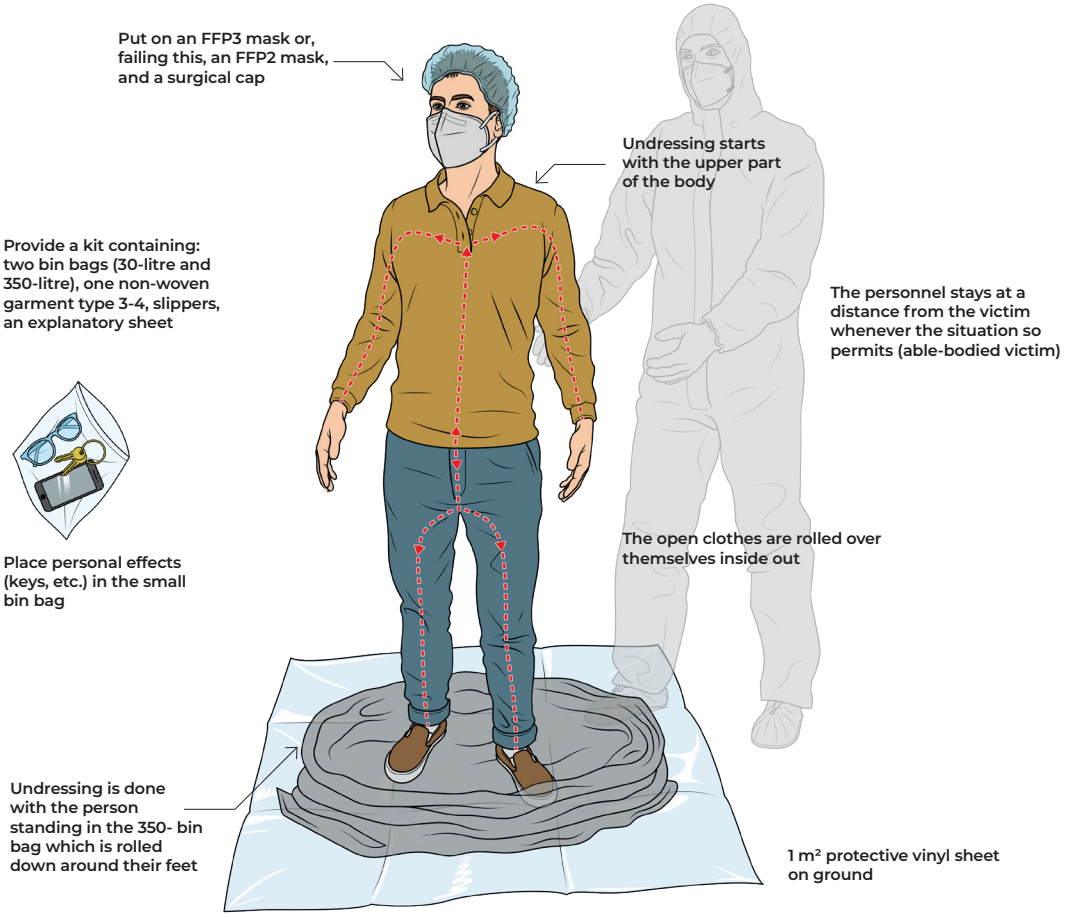
6. **Personnel protection:** change the first pair of gloves.



Transfer of the undressed victim to a non-contaminated bed or stretcher

i The victim is transferred to either the operating theatre or radiology (scanner, etc.), or to the decontamination zone for full decontamination, depending on the medical-surgical urgency.

UNDRESSING DIAGRAM FOR STANDING VICTIMS

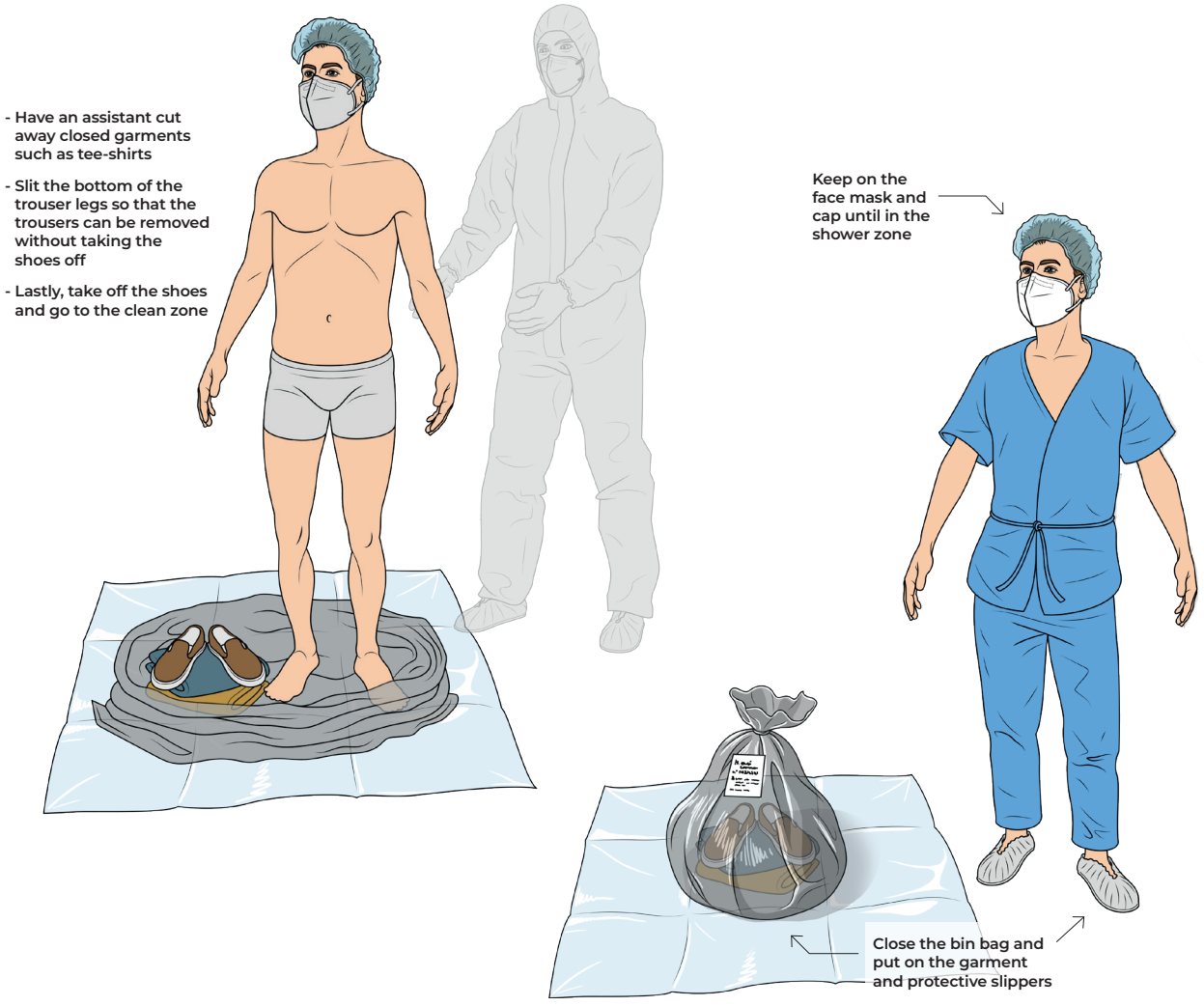


1. **Place a vinyl sheet measuring 1 metre by 1 metre on the ground, and then place an open 350-litre bin bag on it, rolled down inside out.** This operation is to be carried out by two operators called "undressers", kitted out with appropriate Personal Protective Equipment (PPE).

2. **Stand the victim in the centre of the sheet and open their clothes:**
   - at the sleeves: start from the collar (neck)working towards the hands;
   - at the front closure of the jacket or coverall.

   As opening proceeds, roll the clothes over themselves, turning them inside out. **The contamination deposited on the surface of the clothes is thus confined.**

3. **Slit the bottom of trouser legs so that the trousers can be removed without taking the shoes off,** and open the trousers at the waist and roll them fully down over themselves.



4. **Proceed layer by layer:** the top layers of clothing and then, if possible, the underwear.

5. **Once undressed,** the victim takes off socks and shoes and steps out of the bin bag, dons the non-woven garment and slippers and goes to the decontamination zone.

6. **Close the bin bag containing the contaminated clothing, indicate the identity of the victim on it, then store it in the zone designated** "radioactive waste" for radioactive decay or subsequent removal by the National Radioactive Waste Management Agency (Andra) if long-lived waste is involved.

7. **The undressers change their outer pair of gloves.**

i Every 10 victims, check the contamination level of the square vinyl sheets with a low-level radioactivity detector (Geiger-Muller counter with narrow window or equivalent). If contamination is present, change the vinyl square.

SHEET 34

ACTION TO TAKE IN A 1ST LINE HEALTHCARE FACILITY

Decontaminating the victims

Responders
- Hospital decontamination teams

When victims have missed the prehospital screening, the hospital decontamination aims to allow their medical care and to protect the hospital personnel and infrastructure. The protocol indicated below applies after undressing the victim.

1 Detect the contamination (localise the skin contamination)

SEE SHEET 32

2 Carry out emergency decontamination

Undressing greatly reduces the external contamination. SEE SHEET 33

The external contamination is localised on the exposed parts of the body and on wounds. **Caution, long hair is likely to retain a lot of contamination.**

3 Carry out full decontamination (showering that is not aggressive for the skin)

See treatment protocol on next page.

4 Carry out a contamination check

- **After drying:** check the decontaminated zones carefully with a detection probe that is appropriate for the type of radiation emitted by the contaminant.
- **Detecting alpha radiation is a very difficult and long process.** The short path of alpha radiation requires the surface to be absolutely dry. Alpha emitters also emit X-rays or gamma rays whose detection is always easier and morereliable.
- **If the check is positive:** perform a 2nd decontamination, then a contamination check applying the same rules. If the check is still positive, these operations are repeated the following days. After two decontaminations, the residual external contamination is perfectly fixed and presents no risk of dispersion.

5 Redressing the victim

- **Dress in hospital pyjamas or gown or scrub suit.**
- **Continue the medical pathway.** At this stage, there is no risk of the victim transferring external contamination.

FULL DECONTAMINATION: TREATMENT PROTOCOL

CONTAMINATION ON HEALTHY SKIN

First-line treatment: wash with tepid water and mild soap or, if available, a product specifically suited to the radionuclides causing the external contamination, working from the periphery towards the centre of the contaminated zone.

"Detection – decontamination – drying" sequence to be repeated 2 times if necessary.

Case of contamination withstanding two successive washings[11]:

- Cover the contaminated skin zone with a cotton or osmogel dressing and a light plastic film.
  In the case of contamination of the hand, use a cotton glove covered with plastic or a rubber glove.
- Leave in place for 1 to 2 hours to facilitate perspiration, then wash the zone and repeat the treatment if necessary.

Case of contamination by actinides or certain metals: pour directly over the healthy skin one or more vials of Ca-DTPA.

With a local treatment, this route can be used as a complement to the IV route.

SEE radionuclides handbook

Case of risk of contamination by radioactive iodine: apply Lugol's solution.

SEE SHEET 39 + radionuclides handbook (RH24)

Other examples of treatments on the market which show a degree of effectiveness against various targeted radionuclides (actinides, caesium – RH 25, cobalt, etc.) or which show comparable effectiveness in certain utilisation situations: Trait Rouge® cleansing gel and Cevidra® cream (washing and decontaminating cream containing calixarene, a chelator of uranium and other elements).

EYE CONTAMINATION

Wash with physiological serum (saline solution). In cases of contamination by a radionuclide that can be chelated by Ca-DTPA, this product can be used as a solution diluted to 10%.

CONTAMINATED SKIN PUNCTURE, WOUND OR BURN

- **Immediate action:** pour vials of a chelating agent (Ca-DTPA) over the wound or burn in cases of contamination by actinides (this minimises the retention of radionuclides and speeds up their elimination).
- **Protect the wound with an impermeable dressing made up of sterile compresses** attached by an impermeable adhesive or by an occlusive dressing of cream-under-glove type to facilitate transportation of the contaminated person and their treatment in the surgical environment.

SEE SHEET 31 *Contaminated wound treatment protocol*

CONTAMINATION OF THE HAIR SYSTEM

Possibly treat by shaving, but never use a mechanical razor (they cause micro-lesions of the skin which foster retention of the contamination, decontamination becomes difficult if not impossible if one wants to reduce contamination to a very low level).

IF THE CLINICAL CONDITION OF THE PATIENT DETERIORATES: STOP THE DECONTAMINATION PROCESS

The decontamination operations are long and require the victim to in a stable clinical condition. The decontamination operations must be stopped in order to administer medical-surgical treatment if there is any deterioration in the patient's condition.

11. According to the TMT Handbook 2009, washing operations must be stopped if signs of skin irritation appear, if the reduction in contamination through washing becomes less than 10% or if the level of residual contamination is less than 2 times the background radiation.

SHEET 35

ACTION TO TAKE IN A 1ST LINE HEALTHCARE FACILITY

Treating the injured persons in the operating theatre

Responders
- Healthcare facility personnel: RRH RN and other 1st line healthcare facilities

Before a surgical intervention, the patient is undressed if possible in a dedicated room identified in advance.

Adapt the medical management

TYPE OF PATIENT	LEVEL OF RISK	APPLICABLE MEASURE
Decontaminated: no external contamination	None	Usual precautions (personnel in usual operating theatre clothing).
Has fixed contamination	Low	Dedicated (or protected) operating theatre and medical team in surgical clothing.
Incompletely decontaminated For example: non-decontaminated wound	Moderate	Dedicated operating theatre and medical team protected (Personal Protective Equipment – PPE – appropriate for the operating theatre).
Cases of Absolute Urgency (AU), including Extreme Urgencies (EU): non-decontaminated, sometimes still dressed	High	

Prepare the operating theatre

- **Close the ventilation system:** operating theatres function under positive pressure with or without air recycling. **This ventilation system must be closed.** In the case of an open circuit, it may even be under slight negative pressure.
- **Protect the operating theatre:** install vinyl sheeting (pre-cut, number and draw a positioning plan) and protect the biomedical equipment with transparent covers.

Don appropriate protective equipment (PPE) for the operating theatre

- **Theatre nurses and anaesthesia team:** non-woven garment type 5-6, overboots and FFP3 mask or, failing this, FFP2.
- **Surgical team:** surgical clothing with reinforced protection (orthopaedics gown), overboots and FFP3 mask or, failing this, FFP2 mask, safety glasses.
- **If possible use long-sleeved surgical gloves** (used in obstetrics department), double pair of gloves.

SEE SHEET 30

Particular situations

- **"Stripping" the patient:** if the victim has not been intubated, it is vital to protect the respiratory tract at this stage.
- **Bronchial aspiration:** keep the suction probe to measure the contamination.
- **Wound:** prepare the skin, working from the periphery towards the centre. Trim the wounds using detection equipment. The use of an intraoperative probe set to X-ray mode to detect sentinel nodes is an interesting option.
- **Tissue excision:** send the tissues (see sampling procedure) for anatomopathological examination.

SHEET 36

ACTION TO TAKE IN A 2ND OR 3RD LINE HEALTHCARE FACILITY

Receiving the victims

Responders
- Personnel of the 2nd and 3rd-line healthcare facilities

The 2nd and 3rd line facilities must ensure the minimum response when potentially contaminated persons self-present at the facility. The victims may self-present or be brought in by third parties. These are not cases of Absolute Urgency (AU), but there is always a possibility that their condition will deteriorate.

Simply undressing people removes up to 90% of the external contamination.

The healthcare facility must organise and guide victim undressing in accordance with the emergency decontamination procedure described below.

STEP 1 **Receive the victims in the external zone or the room** (well ventilated).

(Hospital Victim Assembly Area – HVAA) planned for these situations, with markings that establish a route between the entrance and a waiting area.

STEP 2 **Give each patient a "contaminated victim" kit.**

- A 350-litre bin bag over which the patient gets undressed.
- A 10-litre bin bag for personal effects.
- An FFP3 mask or, failing this, an FFP2 mask.
- A surgical cap.
- Overshoes.
- A survival blanket.
- A bracelet with labels.

STEP 3 **Guide the patients.**

(A3-format posters with pictograms must be planned for). Uninjured persons shall be able to undress themselves, but they must be guided.

STEP 4 **Put identification on the personal effects bags.**

STEP 5 **Direct the patients to the full decontamination unit.**

It is defined by the Regional Health Agency.

VICTIM REQUIRING TREATMENT IN THE OPERATING THEATRE

Insofar as possible, these victims are sent to a 1st line healthcare facility, unless they are in a life-threatening condition, in which case they will be treated in the receiving facility if it has appropriate technical platform. In this case apply procedure of SHEET 35.

Protecting the personnel

- In a healthcare facility, the personnel ensuring the emergency management of potentially contaminated people must wear Personal Protective Equipment (PPE): a non-woven garment of category III, type 5-6 and an FFP3 mask or, failing this, an FFP2 mask.
- **The choice of clothing depends on the place and whether decontamination has been carried out or not:** refer to the table below.

INTERVENTION CONTEXT	EQUIPMENT
Victims previously decontaminated (full decontamination in the field)	Usual work clothing. **Gloves and surgical mask recommended** (the risks of contamination and irradiation are inexistent or very low).
Intervention at the HVAA after confirmation that there is no chemical contamination	Non-woven coverall, FFP3 mask, surgical cap, safety glasses, overshoes or overboots.
Intervention with individual victims given medical care in the emergency department in the field	
If in a life-threatening condition, surgical treatment, after emergency decontamination, on condition that the facility has an operating theatre	The risk of contamination of the personnel and the infrastructure is low because the surgical intervention is targeted on the anatomical zone which has undergone emergency decontamination. **All the responders must be listed and be subject to specific follow-up by the occupational medicine service.** **Protective clothing (PPE) appropriate for the operating theatre:** - non-woven coverall type 5-6, overboots and FFP3 mask or, failing this, FFP2 mask: **for the theatre nurses and the anaesthesia team;** - surgical clothing with reinforced protection (orthopaedics gown), overboots and FFP3 mask or, failing this, FFP2 mask, safety glasses: **for the surgical team**. If possible use long-sleeved surgical gloves (used in obstetrics department), double pair of gloves.

For further information on the PPE

SEE SHEET 6

Personnel dressing and undressing

SEE SHEET 30

SHEET 37

INTERNAL CONTAMINATION MEASUREMENTS AND TREATMENTS

Internal contamination measurements

Responders
- IRSN
- SPRA (Armed Forces Radiological Protection Service)
- OHS (Occupational Health Service) and the medical biology laboratory of the CEA, EDF and Orano

Three types of examination can be carried out to detect internal contamination by radionuclides: analysis of nasal samples, radiotoxicological analyses of urines and faeces, *in vivo* measurements.

Check the internal contamination

- **If the means are already available in the facility, direct the victim** to the mobile *in vivo* measurement and/or portable spectrometry means for the internal contamination check.
- **Otherwise, depending on the radionuclides involved, the victim may be asked to undergo in vivo measurement** in mobile or fixed facilities and/or collection of excreta at a later date.

The examinations

Positive nasal samples strongly suggest internal contamination; to be confirmed by urine and faeces analysis analyses or *in vivo* measurements. Caution: if a sample gives negative results, this does not necessarily exclude the presence of internal contamination.

The urine and faeces analysis and *in vivo* measurements serve to identify and quantify contaminating radionuclides. The dose received by the contaminated person can be calculated from the measured activities, the time elapsed between contamination and measurement (or sampling) and the circumstances of the accident. The choice of the measurement(s) to take depends on the contaminating element, the contamination route (inhalation, ingestion or wound) and the time elapsed since the contamination.

Take nasal samples

- **The samples on swabs, "flags" or paper tissues must be taken within one hour following contamination *via* the respiratory tract**, because of the rapid transit of the particles in the rhino-pharyngeal region.
- **Place the samples in tubes or plastic bags** and send them to the Institute of Radiation Protection and Nuclear Safety (IRSN) or any radiotoxicology laboratory capable of conducting this type of analysis.

Carry out the urine bioassay

The medical biology laboratory measures the activity of the alpha, beta, or gamma-X emitting radionuclides excreted in the urines. The sample may undergo a chemical treatment prior to measurement in certain cases.

- Start urine collection as soon as possible after contamination. The urine must be collected over 24 h.
- Collect the urine in plastic containers without a preserving agent if they are taken to the laboratory within less than 48 hours. If possible, keep at a temperature of +4°C.
- Identify individually and time stamp each sample correctly before dispatching them.
- Send the samples to IRSN or any other accredited radiotoxicology laboratory: list of accredited organisations for individual dosimetric monitoring (internal dosimetry) downloadable.

Carry out the faeces bioassay

The medical biology laboratory measures the activity of the alpha, beta, gamma or X-ray emitting radionuclides excreted in the faeces. The sample may undergo a chemical treatment prior to measurement in certain cases.

- Collect the faeces as soon as possible after contamination (and over 3 days in succession if possible).
- Keep the samples at a temperature of +4°C if possible.
- Identify individually and time stamp each sample correctly before dispatching them.
- Send the samples to IRSN or any other accredited radiotoxicology laboratory: list of accredited organisations for individual dosimetric monitoring (internal dosimetry) downloadable.

In vivo measurement: for internal contamination by gamma (or X-ray) emitters

- *In vivo* measurement is only indicated for internal contamination by gamma (or X-ray) emitters. It measures the radionuclides present in the organism: detection of gamma and X-ray radiation and quantification of the radionuclides (in the majority of cases) incorporated in the whole body, in the lungs or in the thyroid.
- The subject is placed in front of detectors.
- It necessitates either the use of mobile means (IRSN, Armed Forces Radiological Protection Service – SPRA), or transportation of the person to the fixed facilities (IRSN, SPRA, Basic Nuclear Installations – BNIs).

Mobile means available in France

- Vehicles (trucks or shelters) of IRSN and the SPRA equipped with whole body and thyroid detectors: very effective for the detection of contamination by gamma emitters (*e.g.* iodine-131 or caesium-137).
- The measurement is taken with the person standing or sitting, using a relatively short counting time (about 10 minutes).
- This counting time can be adjusted according to the number of people to undergo radiation measurement and the desired level of activity detection.

© ASN/P. Beuf

Whole body measurement of the thyroid in a laboratory truck (measurement in sitting position).

IRSN mobile *in vivo* measurement laboratories equipped with whole body, lung and thyroid detectors: they give higher levels of performance and can detect low-energy X-ray and gamma ray emitters (*e.g.* americium-241).

The measurement is taken with the person lying down and protected against the ambient radiation, using a longer counting time (about 20 minutes). This time may be adjusted according to several factors: the context, the necessary level of expertise and the number of people to measure).

© Olivier Seignette/Mikaël Lafontan/Médiathèque IRSN

Example of laboratory truck or fixed laboratory system (measurement in lying position).

Fixed *in vivo* measurement facilities: the very low background radiation allows the detection of very low levels of contamination.

Measurements taken on people who are standing (licensees), sitting or lying down using equipment with air renewal and significant shielding to avoid measuring the ambient radiation (radon, cosmic and terrestrial radiation).

CHECK TO CARRY OUT BEFORE TAKING ANY *IN VIVO* MEASUREMENT

Check the external contamination of the person and if necessary perform decontamination (undressing, shower) before taking the measurement.

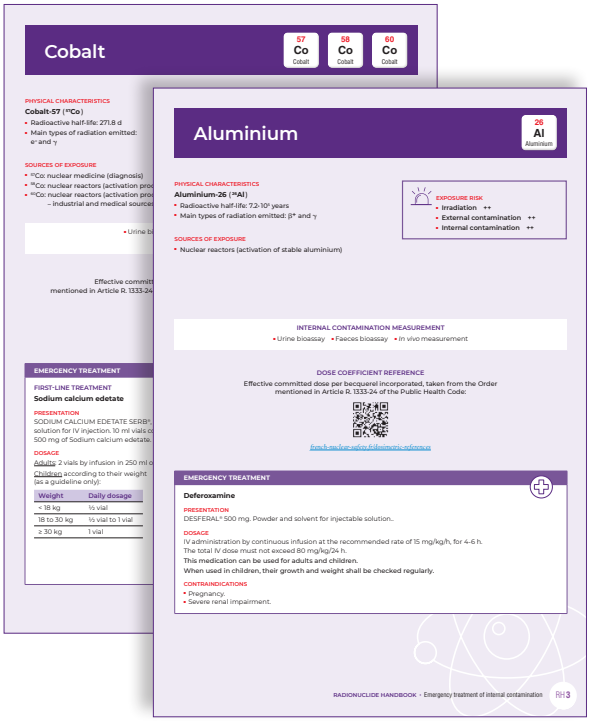
SHEET 38

INTERNAL CONTAMINATION MEASUREMENTS AND TREATMENTS

Internal contamination: initial treatment

Responders
- Medical personnel

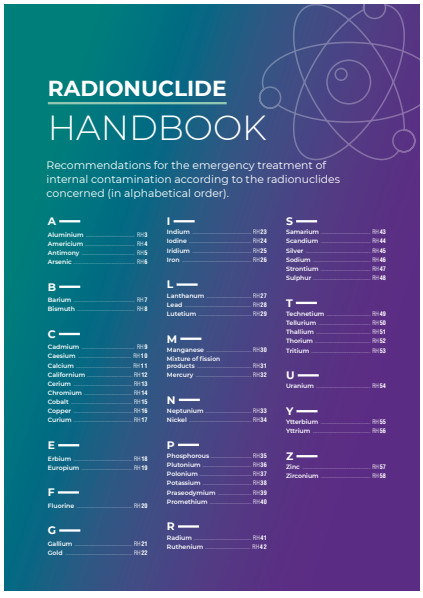
In the event of confirmed (or suspected) internal contamination, the antidotes must be administered as soon as possible.
Whatever the circumstances, the treatment of medical-surgical emergencies takes priority over the evaluation and treatment of contamination.



The radionuclides handbook sheets detail the initial treatment of a person who has, or is suspected of having, internal contamination.

Using the radionuclides handbook

- **The treatments are classed in alphabetical order of the radionuclides.** The dosages cover the first 24 hours of treatment.
- **Each sheet contains physical characteristics of the radionuclides,** information on the sources, the risk of exposure and the available treatments.
- **The major contraindications or special warnings are specified in them.** However, the precautions for use and adverse reactions are not detailed in this guide; they are indicated in the manufacturer's notice.



The emergency therapies proposed in this guide, which are based on the current state of knowledge, use medicines that have a marketing authorisation (MA) or are undergoing studies with a view to obtaining this authorisation issued by the French Health Products Safety Agency (ANSM). Furthermore, stocks of some of these products have been acquired insofar as possible and distributed nationally for use in the pre-hospital and hospital environments.

Reminder: the indication for an internal contamination treatment depends on the dose that would be received if no treatment was administered and the effectiveness of the treatment.

This dose can be:
- calculated from the individual internal contamination measurements SEE SHEET 37;
- or estimated from atmospheric measurements or from the calculations of dispersion of a radioactive source or nuclear releases.

Subsequent treatments

After the first 24 hours, the treatment is adapted according to the patient and the level of contamination. The subsequent treatments are decided by the specialist physicians according to the precise data concerning the event and, if applicable, the first internal contamination measurement results.

The Institute of Radiation Protection and Nuclear Safety (IRSN) can carry out a dosimetric evaluation based on the quantity of radionuclide liable to have been incorporated or the internal contamination measurement results.

Administration of the treatment: points requiring vigilance

- **Persons present near the event, who could have been significantly contaminated:** administer the treatment as early as possible without waiting for the dosimetric evaluation. The treatment depends on the identified potential contaminating radionuclides. For example, potassium iodide tablets for radioactive iodines, Radiogardase® for caesium or Ca-DTPA for actinides.

© McGuff Company, Inc.

- **Potassium iodide tablets: it is very important to start the treatment rapidly.** The tablets prevent the build-up of radioactive iodine in the thyroid, but their effectiveness decreases rapidly (if they are administered more than one hour after contamination).

© Pharmacie centrale des armées

- **The potassium iodide tablets predistributed to the population for administration in the event of a radiological or nuclear (RN) accident, must only be taken when formally instructed to do so by the competent authorities** (Prefect or high command in a military environment).

- **In the event of contamination by radionuclides that do not figure in the radionuclide handbook incorporated in the last part of this guide:** contact the Regional Health Agency which will call upon the crisis centre of the Minister responsible for health.

SHEET 39

INTERNAL CONTAMINATION MEASUREMENTS AND TREATMENTS

Specific antidotes

Below are listed the specific antidotes for treating internal contamination and wounds contaminated by the most commonly encountered radionuclides. The radionuclide handbook incorporated in the last part of this guide is more complete and describers the emergency treatments for all the relevant radionuclides.

Prussian Blue

Iron ferrocyanide

PRESENTATION

RADIOGARDASE® 500 mg capsules (SERB).

INDICATIONS

Internal contamination (ingestion, inhalation, wound): Caesium (RH10), mixture of fission products (RH 31), Indium (RH 23) and Thallium (RH 51).

DOSAGE

- **Adults – Children > 12 years**: 1 g, 3 times a day, *i.e.* 3 g/d.
- **Children 2 to 12 years**: 0.5 g, 3 times a day, *i.e.* 1.5 g/d.
- **Children < 2 years**: no data being available, the administration of Prussian blue must be evaluated with respect to the risks involved.

The capsules must be swallowed with a drink or with foodstuffs; food intake speeds up biliary secretion and the enterohepatic cycle.

With patients who have difficulty swallowing, the capsules can be opened and their content mixed with the food or a liquid (for example, a mannitol solution).

Note that Prussian Blue colours the faeces blue.

Potassium iodide

PRESENTATION

Potassium iodide, 65 mg tablets (PCA – Central Pharmacy of the Armed Forces).

INDICATIONS

Internal contamination (ingestion, inhalation, wound) by iodines (RH 24), mixture of fission products (RH 31) and radioactive tellurium (RH 50).

DOSAGE

- **Adults (including pregnant women) and and children > 12 years**: 2 tablets.
- **Children of 3 to 12 years**: 1 tablet.
- **Children of 1 month to 3 years**: ½ tablet (may be dissolved in water, milk or fruit juice if necessary).
- **Newborns (< 1 month)**: 16 mg, *i.e.* ¼ tablet.

To be effective, the stable iodine must be taken no later than eight hours after contamination.

In the event of a nuclear or radiological accident, the tablets pre-distributed to the public must only be taken when formally instructed to do so by the competent authorities (Prefect or high command in a military environment).

Manufactured by the Central Pharmacy of the Armed Forces (PCA) and available subject to conditions from the Directorate of Health Product Procurements for the Armed Forces (DAPSA-Orléans).

Ca-DTPA

Pentetate calcium trisodium

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. Vial of 4 ml, *i.e.* 1 g of a 25% solution of Ca-DTPA (Central Pharmacy of the Armed Forces).

INDICATIONS

Internal contamination (ingestion, inhalation, wound): Americium (RH 4), Californium (RH 12), Cerium (RH 13), Chromium (RH 14), Cobalt (RH 15), Curium (RH 17), Erbium (RH 18), Europium (RH 19), Indium (RH 23), Iridium (RH 25), Iron (RH 26), Lanthanum (RH 27), Lutetium (RH 29), Manganese (RH 30), mixture of fission products (RH 31), Plutonium (RH 36), Praseodymium (RH 39), Prometheum (RH 40), Ruthenium (RH 42), Samarium (RH 43), Scandium (RH 44), Thorium (RH 52), Ytterbium (RH 55), Yttrium (RH 56), Zinc (RH 57), Zirconium (RH 58).

DOSAGE

- **Adults – Children > 12 years**: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of saline isotonic solution or 5% glucose solution, without exceeding 1 g/d.
- **Children of 2 to 12 years**: slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination:

- **Adults – Children** (to be used with caution): 1 g in a single administration by inhalation by nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds:

Pour one or more vials over the wound.

CONTRAINDICATIONS

None at the recommended dosage.

Manufactured by the Central Pharmacy of the Armed Forces (PCA) and available, subject to conditions, from the Directorate of Health Product Procurements for the Armed Forces (DAPSA-Orléans).

1% iodine solution (Lugol's iodine)

PRESENTATION

LUGOL's iodine (1% potassium iodide – iodine solution) oral drops, prepared by pharmacist.

INDICATIONS

Internal contamination (ingestion, inhalation, wound) by iodides (RH 24) and radioactive tellurium (RH 31 and RH 50).
Lugol's iodine can be used as an alternative to potassium iodide tablets when the latter are not available.
It can also be used for skin contamination, after washing with mild soap and water as th 1st line treatment.

DOSAGE

- **Adults – Children > 12 years**: 80 drops.
- **Children of 3 to 12 years**: 40 drops.
- **Children < 3 years**: 20 drops (Codex dropper).

SHEET 40

INTERNAL CONTAMINATION MEASUREMENTS AND TREATMENTS

Contamination of the digestive tract: non-specific treatments

Below are listed the principle non-specific medicines that can be used for cases of internal contamination by ingestion.

Laxatives

Macrogol 4000

PRESENTATION

FORLAX® 10 g, powder for oral solution in single-dose sachet.

DOSAGE

- **Adults – Children > 8 years**: the usual recommended dose is from 1 to 2 sachets per day, preferably in the morning in a single administration.

The daily dose can be adapted according to the results and can vary from 1 sachet every 2 days (for children in particular) to 2 sachets per day at the most.

Lactulose

PRESENTATION

DUPHALAC® 10 g/15 ml, oral solution in sachet.

DOSAGE

- **Adults – Adolescents**: 1 to 3 sachet(s) per day.
- **Children of 7 to 14 years**: 1 sachet per day.

Gastric buffers

Sodium alginate

PRESENTATION

GAVISCON®, oral suspension in 500 mg sachet of sodium alginate.

DOSAGE

- **Adults**: 10 g/d.

Colloidal aluminium phosphate

PRESENTATION

PHOSPHALUGEL®, oral suspension in single-dose sachet.

DOSAGE

- **Adults**: 1 to 2 sachet(s) per intake, 2 to 3 times/d.

Glossary

A	**AMAD**	Aerodynamic Mean Activity Diameter
	AMP	Advanced Medical Post
	ANSM	French Health Products Safety Agency
	APC	Alert Processing Centre (emergency call centre)
	ARS	Acute Radiation Syndrome
	ASN	French Nuclear Safety Authority
	AU	Absolute Urgencies
B	**BVM**	Bag valve mask
C	**C2IPAV**	Interministerial unit for informing the public and providing aid to victims
	CBC	Complete blood count
	CBRN	Chemical, Biological, Radiological, Nuclear
	CMD	Crisis Medical Director
	CORRUSS-CCS	Operational Cenre for Regulation and Response to Health and Social Emergencies
	CP	Command Post
	CRN	Chemical, Radiological, Nuclear
	CRRC	Call Reception and Regulating Centre (emergency call centre)
D	**DAPSA**	Directorate of Health Product Procurements for the Armed Forces
	DPMA	Deceased Persons Management Area
E	**EOC**	Emergency Operations Commander
	EPMU	Emergency Psycho-Medical Unit
	EU	Extreme Urgencies
F	**FB**	Fire Brigade
	FDA	First Destination Area
	FRS	Fire and Rescue Services
H	**HDU**	Hospital Decontamination Unit
	HEPA	High-Efficiency Particulate Air Filters
	HIS	Hospital Information System
	HVAA	Hospital Victim Assembly Area
I	**ICW**	Infectious Clinical Waste
	IRSN	Institute of Radiation Protection and Nuclear Safety
	ISF	Internal Security Forces

M

MMS	Mobile Medical Station
MOC	Medical Operational Coordinator
MRI	Magnetic Resonance Imaging
MRRU	Mobile Radiological Response Unit

N

NRH RN	National Reference Hospital for the RN risk

O

OHS	Occupational Health Service
ORSAN AMAVI	Organisation of the Healthcare System Response in Exceptional Public Health Situations – Mass reception of non-contaminated victims
ORSAN	Organisation of the Healthcare System Response in Exceptional Public Health Situations
ORSEC	Organisation of the civil security response
ORSEC NOVI	Organisation of the civil security response – Numerous victims

P

PCA	Central Pharmacy of the Armed Forces
PEAA	Personal Effects Assembly Area
PGOC	Police and Gendarmerie Operations Commander
PPE	Personal Protective Equipment

R

RAA	Resources Assembly Area
RES	Radiological Emergency Situation
RN	Radiological, Nuclear
RPE	Radiation Protection Expert
RPS	Radiation Protection Service
RRH RN	Regional Reference Hospital for the RN risk
RRHU	Rapid Response Health Unit
RU	Relative Urgencies

S

SAMU	Emergency Medical Assistance Service
SI-VIC	Victim Tracking Information System
SMUR	Emergency Medical and Resuscitation Service
SSA	Armed Forces Health Service

U

UPAA	Uninjured Persons Assembly Area
UPRC	Uninjured Persons Reception Centre

V

VAA	Victim Assembly Area

Z

ZOC	Zone Operational Centre

RADIONUCLIDE HANDBOOK

Recommendations for the emergency treatment of internal contamination according to the radionuclides concerned (in alphabetical order).

A

Aluminium ..... RH 3
Americium ..... RH 4
Antimony ..... RH 5
Arsenic ..... RH 6

B

Barium ..... RH 7
Bismuth ..... RH 8

C

Cadmium ..... RH 9
Caesium ..... RH 10
Calcium ..... RH 11
Californium ..... RH 12
Cerium ..... RH 13
Chromium ..... RH 14
Cobalt ..... RH 15
Copper ..... RH 16
Curium ..... RH 17

E

Erbium ..... RH 18
Europium ..... RH 19

F

Fluorine ..... RH 20

G

Gallium ..... RH 21
Gold ..... RH 22

I

Indium ..... RH 23
Iodine ..... RH 24
Iridium ..... RH 25
Iron ..... RH 26

L

Lanthanum ..... RH 27
Lead ..... RH 28
Lutetium ..... RH 29

M

Manganese ..... RH 30
Mixture of fission products ..... RH 31
Mercury ..... RH 32

N

Neptunium ..... RH 33
Nickel ..... RH 34

P

Phosphorous ..... RH 35
Plutonium ..... RH 36
Polonium ..... RH 37
Potassium ..... RH 38
Praseodymium ..... RH 39
Promethium ..... RH 40

R

Radium ..... RH 41
Ruthenium ..... RH 42

S

Samarium ..... RH 43
Scandium ..... RH 44
Silver ..... RH 45
Sodium ..... RH 46
Strontium ..... RH 47
Sulphur ..... RH 48

T

Technetium ..... RH 49
Tellurium ..... RH 50
Thallium ..... RH 51
Thorium ..... RH 52
Tritium ..... RH 53

U

Uranium ..... RH 54

Y

Ytterbium ..... RH 55
Yttrium ..... RH 56

Z

Zinc ..... RH 57
Zirconium ..... RH 58

INTRODUCTION

The Radionuclide Handbook contains the recommended emergency treatments of internal contamination according to the radionuclides concerned, with the entries in alphabetical order.

In the event of confirmed or suspected internal contamination, the antidotes must be administered as soon as possible.

The radionuclide sheets have a QR code which provides a link to a page on the ASN website presenting, for each radionuclide, the dose coefficient references taken from the Order mentioned in Article R. 1333-24 of the Public Health Code.

After inhalation, the values indicated correspond to the aerosol form, with an aerodynamic median activity diameter (AMAD) of 1 µm for the public and 5 µm for the workers, and to the type of pulmonary absorption recommended by default in the Order mentioned in Article R. 1333-24 of the Public Health Code.

When the Order mentioned in Article R. 1333-24 of the Public Health Code does not recommend a type of absorption by default, the value is given as a dose range.

For the public, the values are given for adults, other values (usually higher) being applicable for children. **All the dose coefficients figure in the Order mentioned in Article R. 1333-24 of the Public Health Code.**

french-nuclear-safety.fr/dosimetric-references

WARNING

The dosages detailed in these sheets cover the first 24 hours of the recommended initial treatment. The dosage will then be adapted according to the patient and the level of contamination. The precautions for use and adverse reactions are not detailed in this guide; refer to the manufacturer's notice.

Aluminium

26
Al
Aluminium

PHYSICAL CHARACTERISTICS

Aluminium-26 (^{26}Al)

- Radioactive half-life: $7.2 \cdot 10^5$ years
- Main types of radiation emitted: β^+ and γ

SOURCES OF EXPOSURE

- Nuclear reactors (activation of stable aluminium)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Deferoxamine

PRESENTATION

DESFERAL® 500 mg. Powder and solvent for injectable solution..

DOSAGE

IV administration by continuous infusion at the recommended rate of 15 mg/kg/h, for 4-6 h.
The total IV dose must not exceed 80 mg/kg/24 h.

This medication can be used for adults and children.

When used in children, their growth and weight shall be checked regularly.

CONTRAINDICATIONS

- Pregnancy.
- Severe renal impairment.

Americium

241
Am
Americium

PHYSICAL CHARACTERISTICS

Americium-241 (^{241}Am)

- Radioactive half-life: 432.7 years
- Main types of radiation emitted: α and γ

SOURCES OF EXPOSURE

- Nuclear weapons
- Nuclear reactors
- Industrial sources – Smoke detectors

EXPOSURE RISK

- **Irradiation +**
- **External contamination +**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ Lung *in vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Americium-241 (*irsn.fr*).

Antimony

122 Sb Antimony | 124 Sb Antimony | 125 Sb Antimony

PHYSICAL CHARACTERISTICS

Antimony-122 (^{122}Sb)
- Radioactive half-life: 2.7 d
- Main types of radiation emitted: β- and γ

Antimony-124 (^{124}Sb)
- Radioactive half-life: 60.2 d
- Main types of radiation emitted: β- and γ

Antimony-125 (^{125}Sb)
- Radioactive half-life: 2.7 years
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- Nuclear reactors (activation products)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

In the adult, the dose of 1.80 g/d should generally not be exceeded.

With children (< 6 years), the capsules can be opened (to ensure the right dosage) and the powder dissolved in a fruit compote, yoghurt or a drink in order to mask its unpleasant taste and smell.

SECOND-LINE TREATMENT

Only to be administered if Succimer cannot be used.

Dimercaprol

PRESENTATION

B.A.L. solution for intramuscular injection (SERB). 2 ml vials containing 200 mg.

DOSAGE

3 mg/kg body weight and strictly by IM injection, 1 injection every 4 h.

As with all non-aqueous injectable solutions, administer using a glass syringe.

CONTRAINDICATIONS

- Special warning in case of renal impairment.
- Allergy to peanuts.

Arsenic

76
As
Arsenic

PHYSICAL CHARACTERISTICS

Arsenic-76 (^{76}As)

- Radioactive half-life: 1.1 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- Laboratories

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

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Dimercaprol

PRESENTATION

B.A.L. solution for intramuscular injection (SERB). 2 ml vials containing 200 mg.

DOSAGE

3 mg/kg body weight and strictly by IM injection, 1 injection every 4 h.

As with all non-aqueous injectable solutions, administer using a glass syringe.

CONTRAINDICATIONS

- Special warning in case of renal impairment.
- Allergy to peanuts.

Barium

140
Ba
Barium

PHYSICAL CHARACTERISTICS

Barium-140 (^{140}Ba)

- Radioactive half-life: 12.8 d
- Main types of radiation emitted: β- and γ in equilibrium with the Lanthane-140 (period 1.7 d)

EXPOSURE RISK

- **Irradiation ++ ^{140}Ba**
- **External contamination ++ ^{140}Ba**
- **Internal contamination ++ ^{140}Ba**

SOURCES OF EXPOSURE

- Nuclear reactors
- ^{140}Ba: source of Lanthane-140

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Two treatments are possible.

Magnesium sulphate

PRESENTATION

LAVOISIER MAGNESIUM SULPHATE 15% (0.15 g/ml) solution for IV injection. 20 ml vial containing 3 g of Magnesium sulphate heptahydrate (CHAIX ET DU MARAIS LABORATORY).

INDICATIONS

Internal contamination by ingestion.

DOSAGE

Adults: 5 to 10 g by oral route (about 100 mg/kg), *i.e.* 2 to 3 vials of 20 ml.

Sodium alginate

PRESENTATION

GAVISCON®, oral suspension in 500 mg sachet of Sodium alginate.

DOSAGE

Adults: 10 g/d.

Bismuth

207 Bi Bismuth

210 Bi Bismuth

PHYSICAL CHARACTERISTICS

Bismuth-207 (^{207}Bi)

- Radioactive half-life: 33 years
- Main types of radiation emitted: X and γ

Bismuth-210 (^{210}Bi)

- Radioactive half-life: 5 d
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- ^{210}Bi: decay product of Uranium-238
- Nuclear reactors

EXPOSURE RISK

- **Irradiation ++ ^{207}Bi**
- **External contamination ++ ^{207}Bi and ^{210}Bi**
- **Internal contamination ++ ^{207}Bi**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement (^{207}Bi only)

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

In the adult, the dose of 1.80 g/d should generally not be exceeded.

With children (< 6 years), the capsules can be opened (to ensure the right dosage) and the powder dissolved in a fruit compote, yoghurt or a drink in order to mask its unpleasant taste and smell.

Cadmium

109
Cd
Cadmium

PHYSICAL CHARACTERISTICS

Cadmium-109 (^{109}Cd)

- Radioactive half-life: 462.6 d
- Main types of radiation emitted: γ

SOURCES OF EXPOSURE

- Nuclear reactors

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

The use of Succimer is recommended for children.

FIRST-LINE TREATMENT

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

In the adult, the dose of 1.80 g/d should generally not be exceeded.

With children (< 6 years), the capsules can be opened (to ensure the right dosage) and the powder dissolved in a fruit compote, yoghurt or a drink in order to mask its unpleasant taste and smell.

SECOND-LINE TREATMENT

Sodium calcium edetate

PRESENTATION

SODIUM CALCIUM EDETATE SERB®, 50 mg/ml, solution for IV injection. 10 ml vials containing 500 mg of Sodium calcium edetate.

DOSAGE

Adults: 2 vials by infusion in 250 ml of saline.

Children according to their weight (as a guideline only):

Weight	Daily dosage
< 18 kg	½ vial
18 to 30 kg	½ vial to 1 vial
≥ 30 kg	1 vial

Caesium

134 Cs Caesium

137 Cs Caesium

PHYSICAL CHARACTERISTICS

Caesium-134 (^{134}Cs)

- Radioactive half-life: 2 years
- Main types of radiation emitted: β- and γ

Caesium-137 (^{137}Cs)

- Radioactive half-life: 30.1 years
- Main types of radiation emitted: β- and γ in equilibrium with the Barium-137m

SOURCES OF EXPOSURE

- Nuclear reactors (^{137}Cs fission products – ^{134}Cs activation products)
- Industrial and medical sources (γ)

EXPOSURE RISK

- **Irradiation +++**
- **External contamination +++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Prussian Blue (Iron ferrocyanide)

PRESENTATION

RADIOGARDASE® 500 mg capsules (SERB).

DOSAGE

Persons > 12 years: 1 g, 3 times a day, *i.e.* 3 g/d.

Children (2 to 12 years): 0.5 g, 3 times a day, *i.e.* 1.5 g/d.

Children (< 2 years): no data being available, the administration of Prussian Blue must be evaluated with respect to the risks involved.

The capsules must be swallowed with a drink or with foodstuffs; food intake speeds up biliary secretion and the enterohepatic cycle.

With patients who have difficulty swallowing, the capsules can be opened and their content mixed with the food or a liquid (*e.g.* a mannitol solution).

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Caesium-137 (*irsn.fr*).

Calcium

45 Ca Calcium

47 Ca Calcium

PHYSICAL CHARACTERISTICS

Calcium-45 (^{45}Ca)

- Radioactive half-life: 163 d
- Main types of radiation emitted: β-

Calcium-47 (^{47}Ca)

- Radioactive half-life: 4.5 d
- Main types of radiation emitted: β- and γ in equilibrium with the Scandium-47 (half-life 3.4 d)

SOURCES OF EXPOSURE

- ^{45}Ca: research laboratories

EXPOSURE RISK

- **Irradiation + ^{47}Ca**
- **External contamination ++ ^{45}Ca and ^{47}Ca**
- **Internal contamination + ^{47}Ca**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement (^{47}Ca only)

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Two treatments are possible.

Calcium salts

PRESENTATION

CALCIFORTE® 500 mg, oral solution.
Vial sweetened with sodium cyclamate and sodium saccharine (GRIMBERG SA LABORATORIES).

One 10 ml vial contains 500 mg elemental calcium.

INDICATIONS

Internal contamination by ingestion.

DOSAGE

Adults and children (> 10 years): 6 vials every 6 h by oral route.

Children (6 to 10 years): 3 vials every 6 h by oral route.

Sodium alginate

PRESENTATION

GAVISCON®, oral suspension in 500 mg sachet of Sodium alginate.

DOSAGE

Adults: 10 g/d.

Californium

252
Cf
Californium

PHYSICAL CHARACTERISTICS

Californium-252 (^{252}Cf)

- Radioactive half-life: 2.65 years
- Main types of radiation emitted: α and spontaneous fission neutrons

EXPOSURE RISK

- **Irradiation 0**
- **External contamination 0**
- **Internal contamination ++**

SOURCES OF EXPOSURE

Neutron calibration sources:

- interstitial neutron radiotherapy and endocavitary radiotherapy
- neutron activation analysis

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Cerium

139 Ce Cerium | 141 Ce Cerium | 144 Ce Cerium

PHYSICAL CHARACTERISTICS

Cerium-139 (^{139}Ce)
- Radioactive half-life: 137.6 d
- Main types of radiation emitted: γ and X

Cerium-141 (^{141}Ce)
- Radioactive half-life: 32.5 d
- Main types of radiation emitted: β- and e-

Cerium-144 (^{144}Ce)
- Radioactive half-life: 284 d
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE
- ^{141}Ce and ^{144}Ce: nuclear reactors (fission products)
- Alloys in metallurgy
- Optics, vapour lamps

EXPOSURE RISK
- **Irradiation +**
- **External contamination ++ ^{141}Ce and ^{144}Ce**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT
▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement (^{139}Ce only)

DOSE COEFFICIENT REFERENCE
Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation - nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Chromium

51
Cr
Chromium

PHYSICAL CHARACTERISTICS

Chromium-51 (^{51}Cr)

- Radioactive half-life: 27.7 d
- Main types of radiation emitted: e-, X and γ

SOURCES OF EXPOSURE

- Nuclear medicine (diagnosis)
- Nuclear reactors (activation products)

EXPOSURE RISK

- Irradiation ++
- External contamination ++
- Internal contamination ++

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Chromium-51 (*irsn.fr*).

Cobalt

57 Co Cobalt | 58 Co Cobalt | 60 Co Cobalt

PHYSICAL CHARACTERISTICS

Cobalt-57 (^{57}Co)
- Radioactive half-life: 271.8 d
- Main types of radiation emitted: e- and γ

Cobalt-58 (^{58}Co)
- Radioactive half-life: 70.8 d
- Main types of radiation emitted: β+ and γ

Cobalt-60 (^{60}Co)
- Radioactive half-life: 5.3 years
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- ^{57}Co: nuclear medicine (diagnosis)
- ^{58}Co: nuclear reactors (activation products)
- ^{60}Co: nuclear reactors (activation product) – industrial and medical sources

EXPOSURE RISK

- **Irradiation** +++
- **External contamination** ++ ^{58}Co and ^{60}Co
- **Internal contamination** +++

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:INTERNAL CONTAMINATION MEASUREMENT

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Sodium calcium edetate

PRESENTATION

SODIUM CALCIUM EDETATE SERB®, 50 mg/ml, solution for IV injection. 10 ml vials containing 500 mg of Sodium calcium edetate.

DOSAGE

Adults: 2 vials by infusion in 250 ml of saline.

Children according to their weight (as a guideline only):

Weight	Daily dosage
< 18 kg	½ vial
18 to 30 kg	½ vial to 1 vial
≥ 30 kg	1 vial

SECOND-LINE TREATMENT

Pentetate calcium trisodium

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Copper

64 Cu Copper

67 Cu Copper

PHYSICAL CHARACTERISTICS

Copper-64 (^{64}Cu)

- Radioactive half-life: 12.7 h
- Main types of radiation emitted: β- and β+

Copper-67 (^{67}Cu)

- Radioactive half-life: 2.6 d
- Main types of radiation emitted: β+ and γ

SOURCES OF EXPOSURE

- ^{64}Cu: nuclear medicine

EXPOSURE RISK

- **Irradiation ++ ^{67}Cu and ^{64}Cu**
- **External contamination +++**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Two treatments are possible.

Sodium calcium edetate

PRESENTATION

SODIUM CALCIUM EDETATE SERB®, 50 mg/ml, solution for IV injection. 10 ml vials containing 500 mg of Sodium calcium edetate.

DOSAGE

Adults: 2 vials by infusion in 250 ml of saline.

Children according to their weight (as a guideline only):

Weight	Daily dosage
< 18 kg	½ vial
18 to 30 kg	½ vial to 1 vial
≥ 30 kg	1 vial

Penicillamine

PRESENTATION

TROLOVOL® (ERENPHARMA), tablet containing 0.3 g of Penicillamine.

DOSAGE

Adults: 3 to 5 tablets per day in 2 to 3 doses.

Children: 20 mg/kg/d of body weight, divided into 2 or 3 doses.

CONTRAINDICATIONS

- Haematuric and protein nephropathies.
- Severe haematological disorders.
- Lupus erythematosus, myasthenia gravis, severe dermatoses.
- Allergy to penicillins and cephalosporins, due to the possibility in certain people of cross-allergenicity between the beta-lactamines and D-penicillamine.
- History of severe accidents (medullar aplasia, pemphigus, myasthenia gravis) caused by thiol derivatives (tiopronine, pyritinol).

Curium

242 Cm Curium

244 Cm Curium

PHYSICAL CHARACTERISTICS

Curium-242 (^{242}Cm)

- Radioactive half-life: 163 d
- Main types of radiation emitted: α

Curium-244 (^{244}Cm)

- Radioactive half-life: 18.1 years
- Main types of radiation emitted: α

SOURCES OF EXPOSURE

- Calibration sources
- Nuclear reactors (activation products)

EXPOSURE RISK

- **Irradiation 0**
- **External contamination 0**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Erbium

169
Er
Erbium

PHYSICAL CHARACTERISTICS

Erbium-169 (^{169}Er)

- Radioactive half-life: 9.4 d
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- Nuclear medicine (therapeutic)

EXPOSURE RISK

- **Irradiation 0**
- **External contamination ++**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Europium

152 Eu Europium | 154 Eu Europium | 156 Eu Europium

PHYSICAL CHARACTERISTICS

Europium-152 (^{152}Eu)
- Radioactive half-life: 13.5 years
- Main types of radiation emitted: β- and γ

Europium-154 (^{154}Eu)
- Radioactive half-life: 8.6 years
- Main types of radiation emitted: β- and γ

Europium-156 (^{156}Eu)
- Radioactive half-life: 15.2 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE
- Calibration sources

EXPOSURE RISK
- **Irradiation +++**
- **External contamination +++**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT
▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement

DOSE COEFFICIENT REFERENCE
Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Fluorine

18
F
Fluorine

PHYSICAL CHARACTERISTICS

Fluorine-18 (^{18}F)

- Radioactive half-life: 1.83 h

SOURCES OF EXPOSURE

- Nuclear medicine (diagnosis)

EXPOSURE RISK

- Irradiation +
- External contamination +++
- Internal contamination +

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

No treatment required due to the very short half-life of Fluorine-18 (1.83 h).

to find more IRSN-INRS radionuclide sheet: Radiation protection: Radionuclides. Fluorine-18 (*irsn.fr*).

Gallium

66 Ga Gallium | 67 Ga Gallium | 68 Ga Gallium

PHYSICAL CHARACTERISTICS

Gallium-66 (^{66}Ga)
- Radioactive half-life: 9.4 h
- Main types of radiation emitted: β^+ and γ

Gallium-67 (^{67}Ga)
- Radioactive half-life: 3.3 d
- Main types of radiation emitted: ϵ- and γ

Gallium-68 (^{68}Ga)
- Radioactive half-life: 1.1 h
- Main types of radiation emitted: β^+ and γ

SOURCES OF EXPOSURE

- ^{66}Ga and ^{68}Ga: nuclear medicine (diagnosis)

EXPOSURE RISK

- **Irradiation +++**
- **External contamination +++**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Deferoxamine

PRESENTATION

DESFERAL® 500 mg. Powder and solvent for injectable solution.

DOSAGE

IV administration by continuous infusion at the recommended rate of 15 mg/kg/h, for 4-6 h.
The total IV dose must not exceed 80 mg/kg/24 h.

This medication can be used for adults and children.

When used in children, their growth and weight shall be checked regularly.

CONTRAINDICATIONS

- Pregnancy.
- Severe renal impairment.

to find more IRSN-INRS radionuclide sheet: Radiation protection: Radionuclides. Gallium-67 (*irsn.fr*).

Gold

198
Au
Gold

PHYSICAL CHARACTERISTICS

Gold-198 (^{198}Au)

- Radioactive half-life: 2.7 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

Not indicated

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

In the adult, the dose of 1.80 g/d should generally not be exceeded.

With children (< 6 years), the capsules can be opened (to ensure the right dosage) and the powder dissolved in a fruit compote, yoghurt or a drink in order to mask its unpleasant taste and smell.

SECOND-LINE TREATMENT

Only to be administered if Succimer cannot be used.

Dimercaprol

PRESENTATION

B.A.L. solution for intramuscular injection (SERB). 2 ml vials containing 200 mg.

DOSAGE

3 mg/kg body weight and strictly by IM injection, 1 injection every 4 h.

As with all non-aqueous injectable solutions, administer using a glass syringe.

CONTRAINDICATIONS

- Special warning in case of renal impairment.
- Allergy to peanuts.

Indium

111 In Indium

115m In Indium

PHYSICAL CHARACTERISTICS

Indium-111 (^{111}In)

- Radioactive half-life: 2.8 d
- Main types of radiation emitted: γ

Indium-115m (^{115m}In)

- Radioactive half-life: 4.5 h
- Main types of radiation emitted: e- and γ

SOURCES OF EXPOSURE

- ^{111}In: nuclear medicine (diagnosis)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Prussian Blue (Iron ferrocyanide)

PRESENTATION

RADIOGARDASE® 500 mg capsules (SERB).

DOSAGE

Persons > 12 years: 1 g, 3 times a day, *i.e.* 3 g/d.

Children (2 to 12 years): 0.5 g, 3 times a day, *i.e.* 1.5 g/d.

Children (< 2 years): no data being available, the administration of Prussian Blue must be evaluated with respect to the risks involved.

The capsules must be swallowed with a drink or with foodstuffs; food intake speeds up biliary secretion and the enterohepatic cycle.

With patients who have difficulty swallowing, the capsules can be opened and their content mixed with the food or a liquid (*e.g.* a mannitol solution).

SECOND-LINE TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness. If the victim is unconscious (oral route not available), can be used as a second-line treatment due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

to find more IRSN-INRS radionuclide sheet: Radiation protection: Radionucléides. Indium-111 (*irsn.fr*).

Iodine

123 I Iodine | 125 I Iodine | 131 I Iodine | 132 I Iodine

PHYSICAL CHARACTERISTICS

Iodine-123 (^{123}I)
- Radioactive half-life: 13.2 h
- Main types of radiation emitted: X and γ

Iodine-125 (^{125}I)
- Radioactive half-life: 60 d
- Main types of radiation emitted: e⁻ and X

Iodine-131 (^{131}I)
- Radioactive half-life: 8 d
- Main types of radiation emitted: β⁻ and γ

Iodine-132 (^{132}I)
- Radioactive half-life: 2.3 h
- Main types of radiation emitted: β⁻ and γ

SOURCES OF EXPOSURE

- ^{131}I and ^{132}I: nuclear reactors (fission products)
- ^{123}I, ^{125}I and ^{131}I: nuclear medicine
- ^{125}I: radioimmunology

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement: Thyroid *in vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Potassium iodide

PRESENTATION

Potassium iodide, 65 mg tablets (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: (including pregnant women): 2 tablets.

Children (3 to 12 years): 1 tablet.

Children (1 month to 3 years): ½ tablet (may be dissolved in water, milk or fruit juice).

Newborns (< 1 month): 16 mg, *i.e.* ¼ tablet.

To be effective, the iodine tablet must be taken ideally a few hours before exposure to the radioactive particles and gases and within 8 hours after exposure at the latest.

In the event of a nuclear or radiological accident, the tablets pre-distributed to the public must only be taken when formally instructed to do so by the competent authorities (Prefect or high command in a military environments).

The treatment must not be renewed unless instructed to do so by the competent authorities.

SECOND-LINE TREATMENT

1% iodine solution (Lugol's iodine)

Lugol's iodine can be used as an alternative to Potassium iodide tablets when the latter are not available.

PRESENTATION

LUGOL's iodine (1% potassium iodide – iodine solution) oral drops, prepared by pharmacist.

DOSAGE

Persons > 12 years (> 12 years): 80 drops.
Children (3 to 12 years): 40 drops.
Children (< 3 years): 20 drops (Codex dropper).

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Iodine-123 (*irsn.fr*), Radiation protection: radionuclides. Iodine-125 (*irsn.fr*), Radiation protection: radionuclides. Iodine-131 (*irsn.fr*).

Iridium

192
Ir
Iridium

PHYSICAL CHARACTERISTICS

Iridium-192 (^{192}Ir)

- Radioactive half-life: 73.8 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- Industrial radiography
- Brachytherapy

EXPOSURE RISK

- **Irradiation +++**
- **External contamination ++**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Iron

52 Fe Iron | 55 Fe Iron | 59 Fe Iron

PHYSICAL CHARACTERISTICS

Iron-52 (^{52}Fe)
- Radioactive half-life: 8.3 h
- Main types of radiation emitted: β- and γ

Iron-55 (^{55}Fe)
- Radioactive half-life: 2.7 years
- Main types of radiation emitted: X

Iron-59 (^{59}Fe)
- Radioactive half-life: 44.5 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- ^{59}Fe: nuclear reactors (activation products)
- ^{55}Fe: calibration sources

EXPOSURE RISK

- **Irradiation** +++
- **External contamination** +++
- **Internal contamination** +++

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Deferoxamine

PRESENTATION

DESFERAL® 500 mg. Powder and solvent for injectable solution.

DOSAGE

IV administration by continuous infusion at the recommended rate of 15 mg/kg/h, for 4-6 h. The total IV dose must not exceed 80 mg/kg/24 h.

This medication can be used for adults and children.

When used in children, their growth and weight shall be checked regularly.

CONTRAINDICATIONS

- Pregnancy.
- Severe renal impairment.

SECOND-LINE TREATMENT

Pentetate calcium trisodium

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Lanthanum

140
La
Lanthanum

PHYSICAL CHARACTERISTICS

Lanthanum-140 (^{140}La)

- Radioactive half-life: 40 h
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- Calibration sources
- Nuclear reactors (fission products)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Lead

210
Pb
Lead

PHYSICAL CHARACTERISTICS

Lead-210 (^{210}Pb)

- Radioactive half-life: 22.2 years
- Main types of radiation emitted: α (very low level), β- and X

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

SOURCES OF EXPOSURE

- ^{210}Pb: decay product of Uranium-238

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Two treatments are possible. The use of Succimer is recommended for children.

Sodium calcium edetate

PRESENTATION

SODIUM CALCIUM EDETATE SERB®, 50 mg/ml, solution for IV injection. 10 ml vials containing 500 mg of Sodium calcium edetate.

DOSAGE

Adults: 2 vials by infusion in 250 ml of saline.

Children according to their weight (as a guideline only):

Weight	Daily dosage
< 18 kg	½ vial
18 to 30 kg	½ vial to 1 vial
≥ 30 kg	1 vial

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

In the adult, the dose of 1.80 g/d should generally not be exceeded.

With children (< 6 years), the capsules can be opened (to ensure the right dosage) and the powder dissolved in a fruit compote, yoghurt or a drink in order to mask its unpleasant taste and smell.

Lutetium

177
Lu
Lutetium

PHYSICAL CHARACTERISTICS

Lutetium-177 (^{177}Lu)

- Radioactive half-life: 6.7 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- Nuclear medicine (therapy)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination +++**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Manganese

52 Mn Manganese | 52m Mn Manganese | 54 Mn Manganese

PHYSICAL CHARACTERISTICS

Manganese-52 (^{52}Mn)
- Radioactive half-life: 5.6 d
- Main types of radiation emitted: γ

Manganese-52m (^{52m}Mn)
- Radioactive half-life: 21 min
- Main types of radiation emitted: β+ and γ

Manganese-54 (^{54}Mn)
- Radioactive half-life: 312 d
- Main types of radiation emitted: γ

SOURCES OF EXPOSURE

- ^{54}Mn: nuclear reactors (activation products)

EXPOSURE RISK

- **Irradiation +++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Mixture of fission products

EMERGENCY TREATMENT

First administer potassium iodide (or Lugol's solution if Potassium iodide is not available), then Ca-DTPA, and finally Prussian Blue.

1 Potassium iodide

If not available, Lugol's solution can be used as an alternative. SEE SHEET 39

PRESENTATION

Potassium iodide, 65 mg tablets (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Adults (including pregnant women): 2 tablets.
Children (3 to 12 years): 1 tablet.
Children (1 month to 3 years): ½ tablet (may be dissolved in water, milk or fruit juice).
Newborns (< 1 month): 16 mg, *i.e.* ¼ tablet.

To be effective, the iodine tablet must be taken ideally a few hours before exposure to the radioactive particles and gases and within 8 hours afterwards at the most.

In the event of a nuclear or radiological accident, the tablets pre-distributed to the public must only be taken when formally instructed to do so by the competent authorities (Prefect or high command in a military environments).

The treatment must not be renewed unless instructed to do so by the competent authorities.

2 Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

3 Prussian Blue (Iron ferrocyanide)

PRESENTATION

RADIOGARDASE® 500 mg capsules (SERB).

DOSAGE

Persons > 12 years: 1 g, 3 times a day, *i.e.* 3 g/d.

Children (2 to 12 years): 0.5 g, 3 times a day, *i.e.* 1.5 g/d.

Children (< 2 years): no data being available, the administration of Prussian Blue must be evaluated with respect to the risks involved.

The capsules must be swallowed with a drink or with foodstuffs; food intake speeds up biliary secretion and the enterohepatic cycle.

With patients who have difficulty swallowing, the capsules can be opened and their content mixed with the food or a liquid (*e.g.* a mannitol solution).

Mercury

197 Hg Mercury

203 Hg Mercury

PHYSICAL CHARACTERISTICS

Mercury-197 (^{197}Hg)

- Radioactive half-life: 2.7 d
- Main types of radiation emitted: X

Mercury-203 (^{203}Hg)

- Radioactive half-life: 47 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

Not indicated

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

In the adult, the dose of 1.80 g/d should generally not be exceeded.

With children (< 6 years), the capsules can be opened (to ensure the right dosage) and the powder dissolved in a fruit compote, yoghurt or a drink in order to mask its unpleasant taste and smell.

SECOND-LINE TREATMENT

Only to be administered if Succimer cannot be used.

Dimercaprol

PRESENTATION

B.A.L. solution for intramuscular injection (SERB). 2 ml vials containing 200 mg.

DOSAGE

3 mg/kg body weight and strictly by IM injection, 1 injection every 4 h.

As with all non-aqueous injectable solutions, administer using a glass syringe.

CONTRAINDICATIONS

- Special warning in case of renal impairment.
- Allergy to peanuts.

Neptunium

237
Np
Neptunium

PHYSICAL CHARACTERISTICS

Neptunium-237 (^{237}Np)

- Radioactive half-life: $2.1 \cdot 10^6$ years
- Main types of radiation emitted: α, X and γ (very low levels)

SOURCES OF EXPOSURE

- By-products from nuclear reactors and plutonium production
- Used as a component for neutron detectors

EXPOSURE RISK

- **Irradiation 0**
- **External contamination 0**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

At present there is no effective antidote for contamination by this radionuclide.

Nickel

63 Ni Nickel

65 Ni Nickel

PHYSICAL CHARACTERISTICS

Nickel-63 (^{63}Ni)

- Radioactive half-life: 100 years
- Main types of radiation emitted: β-

Nickel-65 (^{65}Ni)

- Radioactive half-life: 2.5 h
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- Nuclear reactors (activation products)

EXPOSURE RISK

- **Irradiation ++ ^{65}Ni**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

The use of Succimer is recommended for children.

FIRST-LINE TREATMENT

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

In the adult, the dose of 1.80 g/d should generally not be exceeded.

With children (< 6 years), the capsules can be opened (to ensure the right dosage) and the powder dissolved in a fruit compote, yoghurt or a drink in order to mask its unpleasant taste and smell.

OR

Sodium calcium edetate

PRESENTATION

SODIUM CALCIUM EDETATE SERB®, 50 mg/ml, solution for IV injection. 10 ml vials containing 500 mg of Sodium calcium edetate.

DOSAGE

Adults: 2 vials by infusion in 250 ml of saline.

Children according to their weight (as a guideline only):

Weight	Daily dosage
< 18 kg	½ vial
18 to 30 kg	½ vial to 1 vial
≥ 30 kg	1 vial

SECOND-LINE TREATMENT

Dimercaprol

PRESENTATION

B.A.L. solution for intramuscular injection (SERB). 2 ml vials containing 200 mg.

DOSAGE

3 mg/kg body weight and strictly by IM injection, 1 injection every 4 h.

As with all non-aqueous injectable solutions, administer using a glass syringe.

CONTRAINDICATIONS

- Special warning in case of renal impairment.
- Allergy to peanuts.

Phosphorous

32 P Phosphorous

33 P Phosphorous

PHYSICAL CHARACTERISTICS

Phosphorous-32 (^{32}P)

- Radioactive half-life: 14.3 d
- Main types of radiation emitted: β-

Phosphorous-33 (^{33}P)

- Radioactive half-life: 25.6 d
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- ^{32}P: research laboratories
- Nuclear medicine (therapeutic)

EXPOSURE RISK

- **Irradiation 0**
- **External contamination ++**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Aluminium hydroxide

PRESENTATION

MAALOX® stomach pains, Aluminium hydroxide/Magnesium hydroxide (400 mg/400 mg). Sugar-free tablet to be chewed, sweetened with sodium saccharine, sorbitol and maltitol.

DOSAGE

Two tablets at a time, renewable without exceeding 12 tablets per day.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Phosphorous-32 (*irsn.fr*), Radiation protection: radionuclides. Phosphorous-33 (*irsn.fr*).

Plutonium

238 Pu Plutonium | 239 Pu Plutonium | 240 Pu Plutonium

PHYSICAL CHARACTERISTICS

Plutonium-238 (^{238}Pu)
- Radioactive half-life: 87.7 years
- Main types of radiation emitted: α, X and γ (very low levels)

Plutonium-239 (^{239}Pu)
- Radioactive half-life: $2.4 \cdot 10^4$ years
- Main types of radiation emitted: α, X and γ (very low levels)

Plutonium-240 (^{240}Pu)
- Radioactive half-life: 6,563 years
- Main types of radiation emitted: α, X and γ (very low levels)

SOURCES OF EXPOSURE

- Nuclear weapons
- Nuclear reactors (MOX fuel and irradiated fuel)
- ^{238}Pu: space industry

EXPOSURE RISK

- **Irradiation 0**
- **External contamination 0**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- Lung *In vivo* measurement **(if significant presence of ^{241}Am)**

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionucleides. Plutonium-239 (*irsn.fr*).

Polonium

210
Po
Polonium

PHYSICAL CHARACTERISTICS

Polonium-210 (^{210}Po)

- Radioactive half-life: 138.4 d
- Main types of radiation emitted: α

SOURCES OF EXPOSURE

- ^{238}U: decay (daughter) product
- Be-Po neutron source
- Laboratories

EXPOSURE RISK

- **Irradiation 0**
- **External contamination 0**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Succimer

PRESENTATION

SUCCICAPTAL® 100 mg capsules (SERB).

DOSAGE

Children (2 to 11 years), adolescents (12 to 17 years), adults: 10 mg/kg to be administered orally every 8 h (*i.e.* 30 mg/kg/d).

In the adult, the dose of 1.80 g/d should generally not be exceeded.

With children (< 6 years), the capsules can be opened (to ensure the right dosage) and the powder dissolved in a fruit compote, yoghurt or a drink in order to mask its unpleasant taste and smell.

SECOND-LINE TREATMENT

Only to be administered if Succimer cannot be used.

Dimercaprol

PRESENTATION

B.A.L. solution for intramuscular injection (SERB). 2 ml vials containing 200 mg.

DOSAGE

3 mg/kg body weight and strictly by IM injection, 1 injection every 4 h.

As with all non-aqueous injectable solutions, administer using a glass syringe.

CONTRAINDICATIONS

- Special warning in case of renal impairment.
- Allergy to peanuts.

Potassium

42 K Potassium

43 K Potassium

PHYSICAL CHARACTERISTICS

Potassium-42 (^{42}K)

- Radioactive half-life: 12.4 h
- Main types of radiation emitted: β- and γ

Potassium-43 (^{43}K)

- Radioactive half-life: 22.2 h
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- ^{42}K: nuclear medicine

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Potassium chloride

PRESENTATION

LAVOISIER POTASSIUM CHLORIDE 10% (0.10 g/ml).
A 20 ml vial contains 2 g of Potassium chloride.

INDICATIONS

Contamination by ingestion.

DOSAGE

To be administered by oral route.

While monitoring the plasma potassium concentration in hospital:

Weight	Dosage	Quantity of potassium in mmol/kg
0 to 10 kg	1 vial	2.7
10 to 20 kg	2 vials	2.7
20 to 30 kg	3 vials	2.7
30 to 40 kg	3 vials	2.0
40 to 50 kg	4 vials	2.1
> 50 kg	5 vials	2.2

Risk of hyperkalaemia (excessively high potassium concentration) if more than 2 mmol/kg of potassium is administered in the adult and more than 3 mmol/kg of potassium in the child.

The dosage is valid for vials containing 20 ml of 10% Potassium chloride.

Other formats are sold in the form of:

- LAVOISIER POTASSIUM CHLORIDE 10% (0.10 g/ml), 1 vial of 10 ml: the dosage must be increased by 2 (doubled).
- LAVOISIER POTASSIUM CHLORIDE 20% (0.10 g/ml), 1 vial of 10 ml: the dosage remains the same.
- LAVOISIER POTASSIUM CHLORIDE 20% (0.10 g/ml), 1 vial of 20 ml: the dosage must be reduced by 2 (halved).

CONTRAINDICATIONS

The administration of this medication is contraindicated in cases of hyperkalaemia or any situation that could lead to hyperkalaemia (severe renal impairment, acute adrenal insufficiency, decompensated metabolic acidosis).

Praseodymium

143 Pr Praseodymium

144 Pr Praseodymium

PHYSICAL CHARACTERISTICS

Praseodymium-143 (^{143}Pr)

- Radioactive half-life: 13.6 d
- Main types of radiation emitted: β-

Praseodymium-144 (^{144}Pr)

- Radioactive half-life: 17.3 min
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- ^{144}Pr: nuclear reactors (fission products)

EXPOSURE RISK

- **Irradiation 0**
- **External contamination ++**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Promethium

147
Pm
Promethium

PHYSICAL CHARACTERISTICS

Promethium-147 (^{147}Pm)

- Radioactive half-life: 2.6 years
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- Industry (watchmaking)

EXPOSURE RISK

- **Irradiation 0**
- **External contamination ++**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Radium

224 Ra Radium

226 Ra Radium

PHYSICAL CHARACTERISTICS

Radium-224 (^{224}Ra)

- Radioactive half-life: 3.7 d
- Main types of radiation emitted: α
- Decay products: Radon-220 (α), Lead-212 (β- and γ)

Radium-226 (^{226}Ra)

- Radioactive half-life: 1,600 years
- Main types of radiation emitted: α and γ
- Decay products: Radon-222 (α), Lead-210 (β-), Bismuth-210 (β-)

SOURCES OF EXPOSURE

- ^{224}Ra: decay product of Thorium-232
- ^{226}Ra: decay product of Uranium-238
- A very wide range of former uses (industry, medicine, etc.)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination 0**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ Lung *in vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Two treatments are possible.

Magnesium sulphate

PRESENTATION

LAVOISIER MAGNESIUM SULPHATE 15% (0.15 g/ml) solution for IV injection. 20 ml vial containing 3 g of Magnesium sulphate heptahydrate (CHAIX ET DU MARAIS LABORATORY).

INDICATIONS

Internal contamination by ingestion.

DOSAGE

Adults: 5 to 10 g by oral route (about 100 mg/kg), *i.e.* 2 to 3 vials of 20 ml.

Sodium alginate

PRESENTATION

GAVISCON®, oral suspension in 500 mg sachet of Sodium alginate.

DOSAGE

Adults: 10 g/d.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionucleides. Radium-226 (*irsn.fr*).

Ruthenium

103 Ru Ruthenium

106 Ru Ruthenium

PHYSICAL CHARACTERISTICS

Ruthenium-103 (^{103}Ru)

- Radioactive half-life: 39.3 d
- Main types of radiation emitted: β- and γ in equilibrium with Rhodium-103m (radioactive half-life: 56 min)

Ruthenium-106 (^{106}Ru)

- Radioactive half-life: 372.6 d
- Main types of radiation emitted: β- and γ in equilibrium with Rhodium-106 (radioactive half-life: 30 s)

SOURCES OF EXPOSURE

- Nuclear reactors (fission products)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Samarium

153
Sm
Samarium

PHYSICAL CHARACTERISTICS

Samarium-153 (^{153}Sm)

- Radioactive half-life: 1.9 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- Nuclear medicine (therapeutic)

EXPOSURE RISK

- **Irradiation +**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Scandium

46 Sc Scandium

47 Sc Scandium

PHYSICAL CHARACTERISTICS

Scandium-46 (^{46}Sc)

- Radioactive half-life: 83.8 d
- Main types of radiation emitted: β- and γ

Scandium-47 (^{47}Sc)

- Radioactive half-life: 3.4 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- ^{46}Sc: industry (gauges)

EXPOSURE RISK

- **Irradiation + ^{47}Sc**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Silver

110m Ag Silver

111 Ag Silver

PHYSICAL CHARACTERISTICS

Silver-110m (^{110m}Ag)

- Radioactive half-life: 250 d
- Main types of radiation emitted: γ

Silver-111 (^{111}Ag)

- Radioactive half-life: 7.5 d
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- ^{110m}Ag: nuclear reactors

EXPOSURE RISK

- **Irradiation** ++ ^{110m}Ag
- **External contamination** +++ ^{110m}Ag and ^{111}Ag
- **Internal contamination** ++ ^{110m}Ag

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Two treatments are possible.

Sodium chloride

PRESENTATION

LAVOISIER SODIUM CHLORIDE 0.9% infusion solution.

INDICATIONS

Contamination by ingestion, to limit the absorption of silver by inducing its precipitation (as Silver chloride).

DOSAGE

100 ml of saline (0.9% Sodium chloride solution) by oral route.

Penicillamine

PRESENTATION

TROLOVOL® (ERENPHARMA), tablet containing 0.3 g of Penicillamine.

DOSAGE

Adults: 3 to 5 tablets per day in 2 to 3 doses.

Children: 20 mg/kg /d of body weight, divided into 2 or 3 doses.

CONTRAINDICATIONS

- Haematuric and protein nephropathies.
- Severe haematological disorders.
- Lupus erythematosus, myasthenia gravis, severe dermatoses.
- Allergy to penicillins and cephalosporins, due to the possibility in certain people of cross-allergenicity between the beta-lactamines and D-penicillamine.
- History of severe accidents (medullar aplasia, pemphigus, myasthenia gravis) caused by thiol derivatives (tiopronine, pyritinol).

Sodium

22 Na Sodium

24 Na Sodium

PHYSICAL CHARACTERISTICS

Sodium-22 (^{22}Na)

- Radioactive half-life: 2.6 years
- Main types of radiation emitted: β^+ and γ

Sodium-24 (^{24}Na)

- Radioactive half-life: 15 h
- Main types of radiation emitted: β^- and γ

In the event of a criticality accident, the Sodium (Na) present in the organism is partly activated as Sodium-24 (^{24}Na).

SOURCES OF EXPOSURE

- Nuclear medicine
- Research laboratories

EXPOSURE RISK

- **Irradiation ++**
- **External contamination +**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Sodium chloride

PRESENTATION

LAVOISIER HYPERTONIC SODIUM CHLORIDE 10%, ampoule 20 ml vial, 10 g for 100 ml of Sodium chloride solution.

INDICATION

Internal contamination by ingestion.

DOSAGE

To be administered by oral route:

Weight	Dosage	Quantity of sodium in mmol/kg
0 to 10 kg	3 vials	8
10 to 20 kg	6 vials	8
20 to 30 kg	9 vials	8
30 to 40 kg	12 vials	8
40 to 50 kg	13 vials	7
> 50 kg	14 vials	8

Risk of hypernatremia if more than 8 mmol/kg of sodium is administered.

The dosage is valid for vials containing 20 ml of 10% Sodium chloride.

Other formats are sold in the form of:

- LAVOISIER SODIUM CHLORIDE 20% (0.10 g/ml), 1 vial of 10 ml: the dosage remains the same.
- LAVOISIER SODIUM CHLORIDE 20% (0.10 g/ml), 1 vial of 20 ml: the dosage must be reduced by 2 (halved).

CONTRAINDICATIONS

- Hypernatremia.
- Hyperchloremia.
- Severe cases of overhydration and fluid retention, particularly in case of decompensated heart failure or decompensated liver failure (ascetic oedematous syndrome in liver cirrhosis), of pre-eclampsia/ eclampsia.

Strontium

85 Sr Strontium | 89 Sr Strontium | 90 Sr Strontium

PHYSICAL CHARACTERISTICS

Strontium-85 (^{85}Sr)
- Radioactive half-life: 64.9 d
- Main types of radiation emitted: γ

Strontium-89 (^{89}Sr)
- Radioactive half-life: 50.7 d
- Main types of radiation emitted: β-

Strontium-90 (^{90}Sr)
- Radioactive half-life: 28.2 years
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- ^{85}Sr and ^{89}Sr: nuclear medicine
- ^{89}Sr and ^{90}Sr: nuclear reactors (fission products)

EXPOSURE RISK

- **Irradiation** ++ ^{85}Sr
- **External contamination** +++ ^{89}Sr and ^{90}Sr
- **Internal contamination** +++

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Two treatments are possible.

Calcium salts

PRESENTATION

CALCIFORTE® 500 mg, oral solution.
Vial sweetened with sodium cyclamate and sodium saccharine (GRIMBERG SA LABORATORIES).

One 10 ml vial contains 500 mg elemental calcium.

INDICATIONS

Internal contamination by ingestion.

DOSAGE

Adults and children (> 10 years): 6 vials every 6 h by oral route.

Children (6 to 10 years): 3 vials every 6 h by oral route.

Sodium alginate

PRESENTATION

GAVISCON®, oral suspension in 500 mg sachet of Sodium alginate.

DOSAGE

Adults: 10 g/d.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Strontium-90 (*irsn.fr*).

Sulphur

35
S
Sulphur

PHYSICAL CHARACTERISTICS

Sulphur-35 (^{35}S)

- Radioactive half-life: 87 d
- Main types of radiation emitted: β-

In the event of a criticality accident, the Sulphur (S) present in the organism (skin appendages) is partly activated as Sulphur-35 (^{35}S).

EXPOSURE RISK

- **Irradiation 0**
- **External contamination ++**
- **Internal contamination +**

SOURCES OF EXPOSURE

- Research laboratories

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Magnesium sulphate

PRESENTATION

LAVOISIER MAGNESIUM SULPHATE 15% (0.15 g/ml) solution for IV injection. 20 ml vial containing 3 g of Magnesium sulphate heptahydrate (CHAIX ET DU MARAIS LABORATORY).

INDICATIONS

Internal contamination by ingestion.

DOSAGE

Adults: 5 to 10 g by oral route (about 100 mg/kg), *i.e.* 2 to 3 vials of 20 ml.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Sulphur-35 (*irsn.fr*).

Technetium

99m
Tc
Technetium

PHYSICAL CHARACTERISTICS

Technetium-99m (^{99m}Tc)

- Radioactive half-life: 6 h
- Main types of radiation emitted: e- and γ

SOURCES OF EXPOSURE

- Nuclear medicine (diagnosis)

EXPOSURE RISK

- **Irradiation +**
- **External contamination +**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

No treatment required due to the very short half-life of Technetium-99m (6 h).

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Technetium-99m (*irsn.fr*).

Tellurium

132
Te
Tellurium

PHYSICAL CHARACTERISTICS

Tellurium-132 (^{132}Te)

- Radioactive half-life: 3.26 d
- Main types of radiation emitted: β and γ

SOURCES OF EXPOSURE

- Nuclear reactors (fission products)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination +++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

FIRST-LINE TREATMENT

Potassium iodide

PRESENTATION

Potassium iodide, 65 mg tablets (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Adults (including pregnant women): 2 tablets.

Children (3 to 12 years): 1 tablet.

Children (1 month to 3 years): ½ tablet (may be dissolved in water, milk or fruit juice).

Newborns (< 1 mois): 16 mg, *i.e.* ¼ tablet.

To be effective, the iodine tablet must be taken ideally a few hours before exposure to the radioactive particles and gases and within 8 hours after exposure at the latest.

In the event of a nuclear or radiological accident, the tablets pre-distributed to the public must only be taken when formally instructed to do so by the competent authorities (Prefect or high command in a military environments).

The treatment must not be renewed unless instructed to do so by the competent authorities.

SECOND-LINE TREATMENT

1% iodine solution (Lugol's iodine)

Lugol's iodine can be used as an alternative to Potassium iodide tablets when the latter are not available.

PRESENTATION

LUGOL's iodine (1% potassium iodide – iodine solution) oral drops, prepared by pharmacist.

DOSAGE

Persons > 12 years (> 12 years): 80 drops.
Children (3 to 12 years): 40 drops.
Children (< 3 years): 20 drops (Codex dropper).

Thallium

201 Tl Thallium

204 Tl Thallium

PHYSICAL CHARACTERISTICS

Thallium-201 (^{201}Tl)

- Radioactive half-life: 3 d
- Main types of radiation emitted: X and γ

Thallium-204 (^{204}Tl)

- Radioactive half-life: 3.8 years
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- ^{201}Tl: nuclear medicine (diagnosis)

EXPOSURE RISK

- **Irradiation + ^{201}Tl**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Prussian Blue (Iron ferrocyanide)

PRESENTATION

RADIOGARDASE® 500 mg capsules (SERB).

DOSAGE

Persons > 12 years: 1 g, 3 times a day, *i.e.* 3 g/d.

Children (2 to 12 years): 0.5 g, 3 times a day, *i.e.* 1.5 g/d.

Children (< 2 years): no data being available, the administration of Prussian Blue must be evaluated with respect to the risks involved.

The capsules must be swallowed with a drink or with foodstuffs; food intake speeds up biliary secretion and the enterohepatic cycle.

With patients who have difficulty swallowing, the capsules can be opened and their content mixed with the food or a liquid (*e.g.* a mannitol solution).

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Thallium-201 (*irsn.fr*).

Thorium

232
Th
Thorium

PHYSICAL CHARACTERISTICS

Thorium-232 (^{232}Th)

- Radioactive half-life: $1.4 \cdot 10^{10}$ years
- Main types of radiation emitted: α
- Decay products: Radium-228 (β-), Radium-224 (α), Radon-220 (α) and Lead-212 (β- and γ)

SOURCES OF EXPOSURE

- Industry: alloys, electrodes
- Optics
- Mines and rare earth works

EXPOSURE RISK

- **Irradiation 0**
- **External contamination 0**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ Lung *in vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Thorium-232 (*irsn.fr*).

Tritium

T ou ^{3}H
Tritium

PHYSICAL CHARACTERISTICS

Tritium (T ou ^{3}H)

- Radioactive half-life: 12.3 years
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- Calibration sources
- Nuclear reactors (activation products)
- Radioimmunology (molecular marking)

EXPOSURE RISK

- **Irradiation 0**
- **External contamination 0**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

In the event of ingestion of tritiated water, massive hydration (3 to 4 l/d).

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Tritium (*irsn.fr*).

Uranium

235 U Uranium

238 U Uranium

PHYSICAL CHARACTERISTICS

Uranium-235 (^{235}U)

- Radioactive half-life: 7 x 10^8 years
- Main types of radiation emitted: α and γ
- Decay products: Protactinium-231 (α) and Actinium-227 ($\beta\gamma$)

Uranium-238 (^{238}U)

- Radioactive half-life: 4.5 x 10^9 years
- Main types of radiation emitted: α
- Decay products: Uranium-234 (α), Thorium-230 (α), Radium-226 ($\alpha\gamma$) and Lead-210 (α)

SOURCES OF EXPOSURE

- Enriched uranium: nuclear reactors (fuel), nuclear weapons
- Depleted uranium: ballast, biological protections, conventional weapons

EXPOSURE RISK

- **Irradiation 0 to ++ (enriched Uranium)**
- **External contamination + (Decay product: ^{238}U)**
- **Internal contamination +++ (Chemical reaction)**

INTERNAL CONTAMINATION MEASUREMENT

▪ Urine bioassay ▪ Faeces bioassay ▪ Lung *in vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Sodium bicarbonate

PRESENTATION

LAVOISIER SODIUM BICARBONATE 1.4% isotonic solution for infusion (CHAIX ET DU MARAIS LABORATORY).

DOSAGE

Slow infusion, 1 bottle of 250 ml of isotonic solution (1-2 mmol/kg).
Continue the treatment until an urine pH of 8-9 is obtained.

CONTRAINDICATIONS

- Metabolic alkalosis.
- Respiratory acidosis.

The infusion can aggravate or reveal an existing state of hypokalaemia.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionucleides. Natural uranium (*irsn.fr*).

Ytterbium

169
Yb
Ytterbium

PHYSICAL CHARACTERISTICS

Ytterbium-169 (^{169}Yb)

- Radioactive half-life: 32 d
- Main types of radiation emitted: e- and γ

SOURCES OF EXPOSURE

Not indicated

EXPOSURE RISK

- **Irradiation +**
- **External contamination +**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Yttrium

90
Y
Yttrium

PHYSICAL CHARACTERISTICS

Yttrium-90 (^{90}Y)

- Radioactive half-life: 2.7 d
- Main types of radiation emitted: β-

SOURCES OF EXPOSURE

- Nuclear reactors (fission products)
- Nuclear medicine (therapeutic)

EXPOSURE RISK

- **Irradiation +**
- **External contamination ++**
- **Internal contamination +**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

to find more IRSN-INRS radionuclide sheet: Radiation protection: radionuclides. Yttrium-90 (*irsn.fr*).

Zinc

65
Zn
Zinc

PHYSICAL CHARACTERISTICS

Zinc-65 (^{65}Zn)

- Radioactive half-life: 244 d
- Main types of radiation emitted: γ

SOURCES OF EXPOSURE

- Nuclear reactors (activation products)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Pentetate calcium trisodium

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of isotonic saline solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

Zirconium

95
Zr
Zirconium

PHYSICAL CHARACTERISTICS

Zirconium-95 (^{95}Zr)

- Radioactive half-life: 64 d
- Main types of radiation emitted: β- and γ

SOURCES OF EXPOSURE

- Nuclear reactors (activation products)

EXPOSURE RISK

- **Irradiation ++**
- **External contamination ++**
- **Internal contamination ++**

INTERNAL CONTAMINATION MEASUREMENT

- Urine bioassay
- Faeces bioassay
- *In vivo* measurement

DOSE COEFFICIENT REFERENCE

Effective committed dose per becquerel incorporated, taken from the Order mentioned in Article R. 1333-24 of the Public Health Code:

french-nuclear-safety.fr/dosimetric-references

EMERGENCY TREATMENT

Two treatments are possible.

Deferoxamine

PRESENTATION

DESFERAL® 500 mg. Powder and solvent for injectable solution.

DOSAGE

IV administration by continuous infusion at the recommended rate of 15 mg/kg/h, for 4-6 h. The total IV dose must not exceed 80 mg/kg/24 h.

This medication can be used for adults and children.

When used in children, their growth and weight shall be checked regularly.

CONTRAINDICATIONS

- Pregnancy.
- Severe renal impairment.

Pentetate calcium trisodium

No demonstrated clinical effectiveness, but usable due to its good tolerance profile.

PRESENTATION

Ca-DTPA 250 mg/ml, injectable solution. 4 ml vial (PCA – Central Pharmacy of the Armed Forces).

DOSAGE

Persons > 12 years: slow IV injection or infusion in 15 min of a half-vial of Ca-DTPA (*i.e.* 0.5 g), diluted in 100 to 200 ml of saline isotonic solution or 5% glucose solution, without exceeding 1 g/d.

Children (< 12 years): slow IV injection or infusion 14 mg/kg, without exceeding 0.5 g/d.

TREATMENTS COMPLEMENTARY TO INTRAVENOUS ADMINISTRATION

Pulmonary contamination

Adults – Children (to be used with caution): 1 g in a single administration by inhalation – nebulisation only (spray mist, 50/50 dilution of a 4 ml vial in sterile or saline water).

Contaminated wounds

Pour one or more vials over the wound.

AUTORITÉ
DE SÛRETÉ
NUCLÉAIRE

15 rue Louis Lejeune – 92120 Montrouge – France
asn.fr
Centre d'information du public : 33 (0)1 46 16 40 16 • info@asn.fr

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