
# Dose estimation of victims who are accidentally exposed in emergency exposure situations

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# Today’s contents

- ICRP activities about nuclear/radiological accidents
- External dosimetry of victims who are accidentally exposed in non-homogeneous exposure accident
- Summary of the presentation

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- ICRP activities about nuclear/radiological accidents
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# ICRP publications regarding nuclear/radiological accidents

ICRP Publication 40
Protection of the Public in the Event of Major Radiation Accidents - Principles for Planning

ICRP Publication 82
Protection of the Public in Situations of Prolonged Radiation Exposure

ICRP Publication 96
Protecting People against Radiation Exposure in the Event of a Radiological Attack

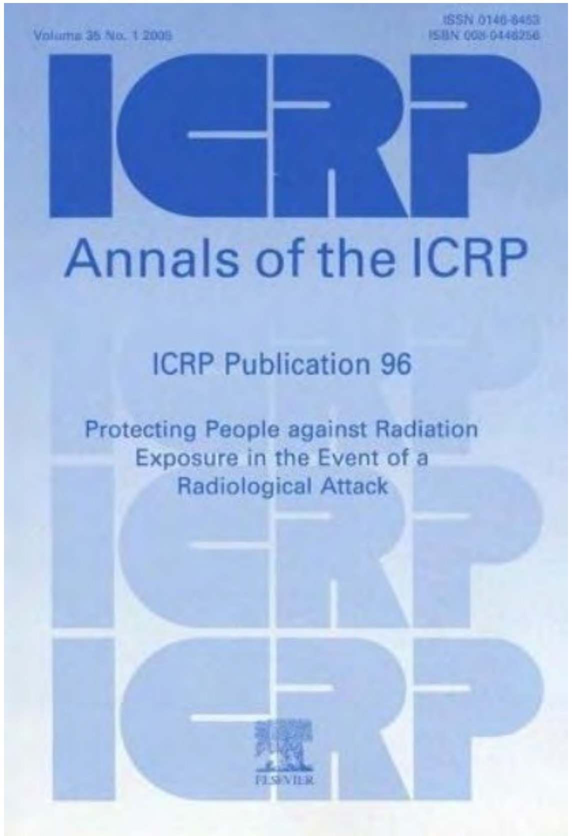
ICRP Publication 109
Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations

ICRP Publication 111
Application of the Commission's Recommendations to the Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident or a Radiation Emergency

ICRP Publication 124
Protection of the Environment under Different Exposure Situations

ICRP Publication 146
Radiological Protection of People and the Environment in the Event of a Large Nuclear Accident

# ICRP publication 96




(7) The main aim of this report is to provide radiological protection recommendations for protecting people's health in the aftermath of a radiological attack.

1. INTRODUCTION
   intended audience -> responsible officials, regulatory bodies, and advisory agencies with competence in emergency response
2. CHARACTERISING THE SITUATION
   potential scenario for radiological attacks
   (dirty bomb, happen in the street)
   Common features for radiological attacks
3. POTENTIAL HEALTH EFFECTS ATTRIBUTABLE TO RADIATION EXPOSURE
4. PROTECTING RESPONDERS
   protect the first responders (the police, fire fighters, paramedics, and other support and intervention services personnel)
5. PROTECTING THE PUBLIC
   Rescue phase (immediate actions, urgent actions),
   Recovery phase, Restoration phase,
6. MEDICAL INTERVENTION
7. COMMUNICATION

https://www.icrp.org/publication.asp?id=ICRP%20Publication%2096 access on 26 Sep 2023

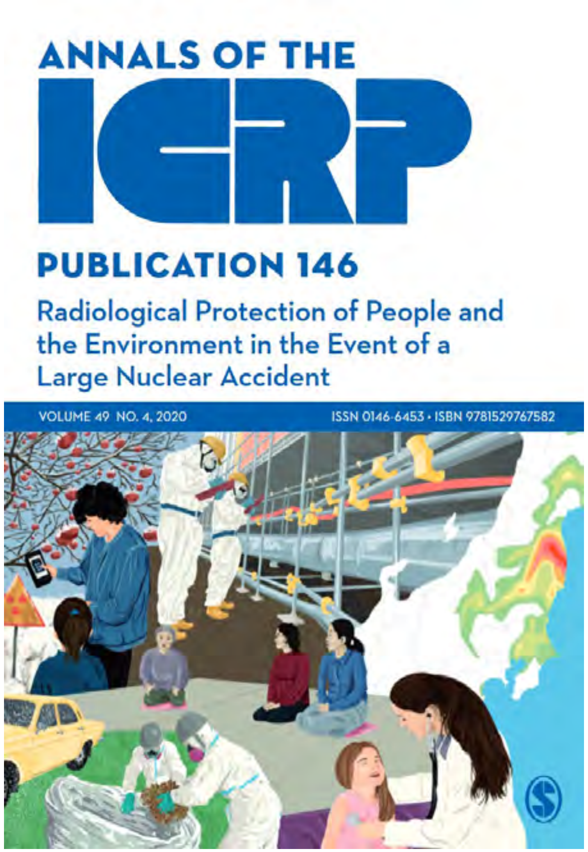
# ICRP publication 96 (2) protecting responders

Table 4.1 Guidance for occupational exposure

| Type of emergency operation | | Dose guidance value |
|---|---|---|
| Rescue operations* | Saving life, preventing serious injury, or actions to prevent the development of catastrophic conditions | In principle, no dose restrictions are recommended if, and ONLY IF, the benefit to others clearly outweighs the rescuer's own risk. Otherwise, every effort should be made to avoid deterministic effects on health (i.e.: effective doses below 1000 mSv should avoid serious deterministic health effects, and below ten times the maximum single year dose limit as given below should avoid other deterministic health effects). |
| | Other immediate and urgent actions to prevent injuries or large doses to many people | • All reasonable efforts should be made to keep doses below twice the maximum single year limits (see below). |
| Other operations, including recovery and restoration operations | | Normal occupational dose limits apply; i.e.:<br>• a limit on effective dose of 20 mSv/year, averaged over 5 years (i.e., a limit of 100 mSv in 5 years), with the further provision that in any single year:<br>• the effective dose should not exceed 50 mSv, and<br>• the equivalent dose should not exceed<br>– 150 mSv for the lens of the eye,<br>– 500 mSv for the skin (average dose over 1 $cm^2$ of the most highly irradiated area of the skin), and<br>– 500 mSv for the hands and feet |

* Under conditions that may lead to doses above normal occupational exposure limits, workers should be volunteers and should be instructed in dealing with radiation hazards to allow them to make informed decisions. Female workers who may be pregnant or nursing should not participate in these operations.

https://www.icrp.org/publication.asp?id=ICRP%20Publication%2096 access on 26 Sep 2023




## MAIN POINTS (an excerpt)

- A large nuclear accident causes a breakdown in society affecting all aspects of individual and community life. It has large and long-lasting societal, environmental, and economic consequences.

- The objective of radiological protection is to mitigate radiological consequences for people and the environment whilst, at the same time, ensuring sustainable living conditions for the affected people, suitable working conditions for the responders, and maintaining the quality of the environment.

- Responsible organisations should promote the involvement of local communities in a co-operative process with experts (co-expertise process) to help achieve a better assessment of the local situation, the development of an adequate practical radiological protection culture, and informed decision-making among those affected.

- Preparedness planning is essential for mitigating the consequences during phases of a large nuclear accident, and should involve stakeholders.

https://www.icrp.org/publication.asp?id=ICRP%20Publication%20146 access on 28 Sep 2023

https://www.icrp.org/publication.asp?id=ICRP%20Publication%20146 access on 28 Sep 2023

# Early and intermediate Phases

## Characteristics

Significant uncertainty concerning current and future status of the source;
Uncertainty about pathways and levels of exposure with potential for high levels of exposure;
Rapid changes of radiological and non-radiological conditions.

## Radiological characterisation

- Exposure pathways
- Environmental and individual monitoring

## Protection of responders

- diverse in terms of their status, exposure largely varies -> graded approach
- should be less than 100 mSv during the whole phases

## Protection of the public and the environment

Early phase :
Sheltering, Evacuation and temporary relocation, Iodine thyroid blocking, Decontamination of people, and Precautionary restrictions of foodstuffs
Intermediate phase :
Temporary relocation, Foodstuff management, Management of other commodities, Decontamination of the environment, and Management of business activities

https://www.icrp.org/publication.asp?id=ICRP%20Publication%20146 access on 28 Sep 2023

# Long-term Phase

## Characteristics of the long-term phase

"beyond the consideration of radiological aspects, the rehabilitation of living and working conditions after a large nuclear accident is a complex process in which all dimensions of individual and community life are involved and interconnected."

## Protection of responders during the long-term phase

For responders on-site, setting a reference level of 20 mSv per year or below is recommended

For public areas, the reference level should be within the lower half of the 1–20 mSv per year band

## Protective actions for the long-term phase

Decontamination and waste management

Agriculture, fisheries, and foodstuff management

Economic and business activities

## Health surveillance

## Accompanying measures

# ICRP publication 146　reference levels for optimisation

Table 6.1. Reference levels for guiding the optimisation of protection of responders and members of the public during the successive phases of a nuclear accident.

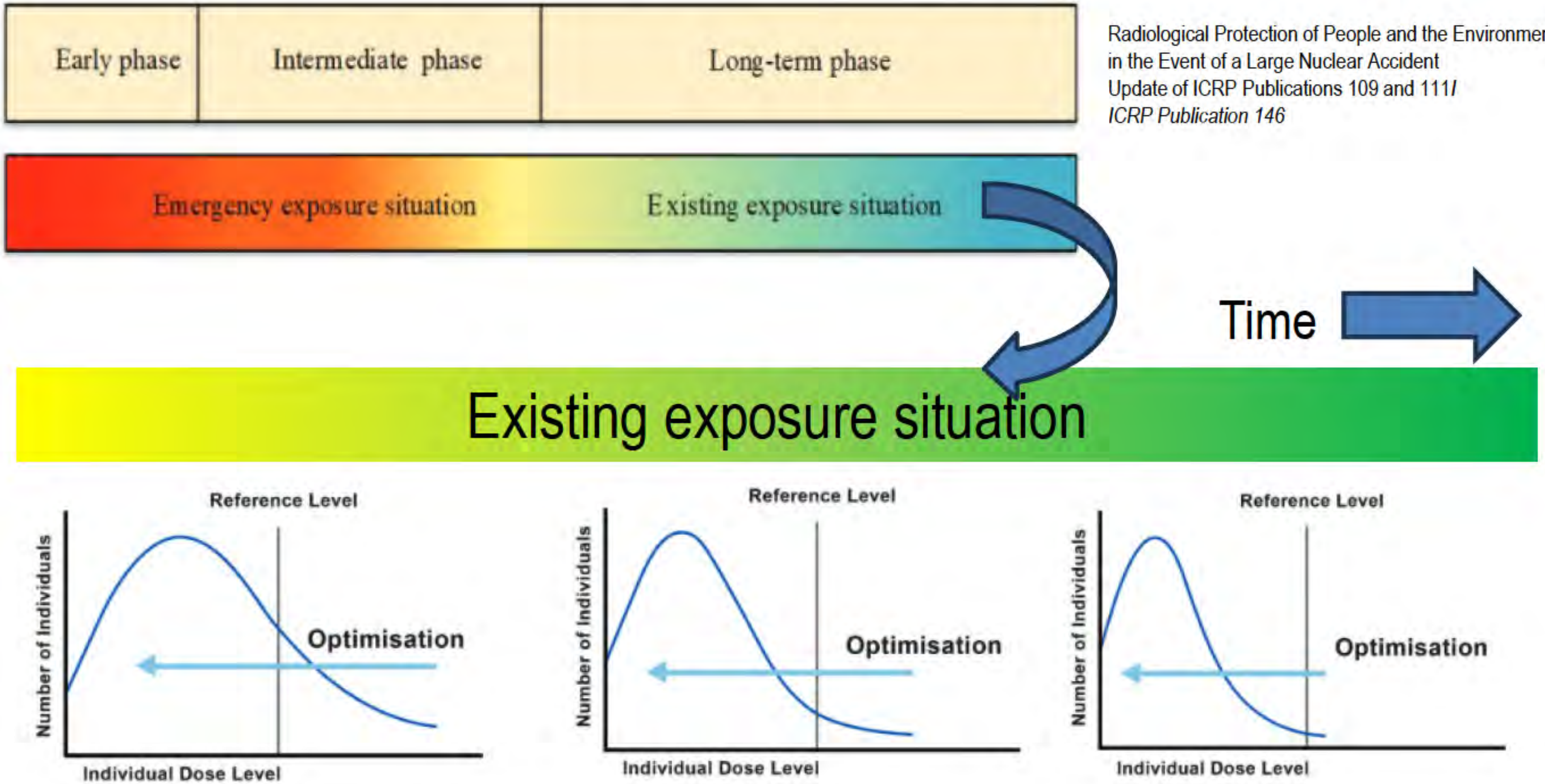
| | Early Phase | Intermediate Phase | Long-Term Phase |
|---|---|---|---|
| Responders on-site | 100 mSv or below* Could be exceeded in exceptional circumstances† | 100 mSv or below* May evolve with circumstances*†‡ | 20 mSv per year or below |
| Responders off-site | 100 mSv or below* Could be exceeded in exceptional circumstances† | 20 mSv per year or below‡ May evolve with circumstances | 20 mSv per year or below in restricted areas not open to the public<br><br>Lower half of the 1 to 20 mSv per year band in all other areas¶ |
| Public | 100 mSv or below for the entire duration of both the early and intermediate phases§ | | Lower half of the 1 to 20 mSv per year band with the objective to progressively reduce exposure to levels towards the lower end of the band, or below if possible¶ |

*Previously, the Commission recommended selection of reference levels in the band of 20–100 mSv for emergency exposure situations. The current recommendations recognise that the most appropriate reference levels may be lower than this band under some circumstances.
†The Commission recognises that higher levels in the range of a few hundred millisieverts may be permitted to responders to save lives or to prevent further degradation at the facility leading to catastrophic conditions.
‡As some responders may be involved in both the early and intermediate phases, the management of exposures should be guided by the objective to keep the total exposure during these phases below 100 mSv.
§Previously, the Commission recommended the selection of reference levels in the band of 20–100 mSv for emergency exposure situations. The current recommendation recognises that, in some circumstances, the most appropriate reference level may be below 20 mSv.
¶This clarifies the expression 'lower part' as used in *Publication 111*.

https://www.icrp.org/publication.asp?id=ICRP%20Publication%20146 access on 28 Sep 2023

## Schematic illustration of the evolution of the distribution of individual exposures with time as a result of implementing the optimisation process with a reference level.

Radiological Protection of People and the Environment in the Event of a Large Nuclear Accident
Update of ICRP Publications 109 and 111
*ICRP Publication 146*




Reference level:
Set between 1 mSv/year and 20 mSv/year depending on the situation
-> Reduce reference level to 1 mSv/year or less, depending on the situation

The 2007 Recommendations of the International Commission on Radiological Protection
*ICRP Publication 103*

# Radiological Protection for Radiation Emergencies and Malicious Events

A Task Group under Committee 4

The updated report will replace these criteria with Reference Levels (residual effective dose) for optimising protection during the planning and implementation of protective actions in both emergency and existing exposure situations.

Updating and broadening the scope of Publication 96 to include a wide range of radiation emergencies that are not large-scale nuclear accidents.
Not limited to transport accidents, fires and other events causing damage to sites holding radioactive materials, and inadvertent damage to sealed sources (e.g., Windscale Fire, Kyshtym, Goiania and Tokaimura accidents).
Malicious use of radioactive materials will include the targeted poisoning of individuals, radiological dispersal devices, theft of radioactive materials and radiopharmaceuticals from facilities or during transport, covert radiological exposure devices, deliberate contamination of food and water supplies, sabotage of nuclear facilities, and nuclear detonations of limited size.

https://www.icrp.org/icrp_group.asp?id=186 access on 28 Sep 2023

# Advice for the Public on Protection in Case of a Nuclear Detonation

## THIS SCIENTIFICALLY SUPPORTED ADVICE COULD BE LIVESAVING

*Although we hope this information will never need to be put into action, ICRP has summarised publicly available information on protection in case of nuclear detonation here and, in partnership with SAGE publishing UK, has made ICRP Publication 146 Radiological Protection of People and the Environment in the Event of a Large Nuclear Accident immediately free to access. Meanwhile, ICRP Task Group 120 is developing protection guidance on other radiation emergencies and malicious events and more detailed advice for authorities and the public in case of a nuclear detonation.*

**A nuclear detonation may occur without warning. It may result in mass casualties.**

**There are steps you can take to protect yourself and your family from the radiation after a nuclear detonation.**

**Go inside and stay inside. Get inside the center of a building or basement to put as much material between you and the radioactive material outside.**

THE FIRST 10 MINUTES
THE FIRST 24 HOURS
THE NEXT 48 HOURS
UNDERSTAND THE HAZARDS
HOW TO BE PREPARED FOR A NUCLEAR DETONATION
RESPONDING TO ALERTS

https://www.icrp.org/page.asp?id=620

## THE FIRST 10 MINUTES

A nuclear detonation, whether from a missile or small portable device, may result in mass casualties. Adequate preparation and appropriate response to a nuclear alert or detonation can protect you and your family's health and life. **The best way to protect you and your family before, during, and after a nuclear blast is getting inside the centre of a building or basement.** On August 6, 1945, Mr Eizo Nomura was in the basement of a building in Hiroshima, about 170 meters from ground zero. He survived the atomic bombing and died in 1982 at the age of 84 [ref]. Most people within a few hundred metres of a nuclear detonation are not likely to survive, especially if unprepared.

**Be inside before the fallout arrives.** After a detonation, you will have 10 minutes or more to find an adequate shelter before fallout arrives. If a multi-story building or a basement can be safely reached within a few minutes of the explosion, go there immediately. The safest buildings have brick or concrete walls. Underground parking garages and subways can also provide good shelter.


**The best thing you can do after a nuclear detonation is go inside. Put as much material as possible between you and the radioactive material outside.**

https://www.icrp.org/page.asp?id=620

- Publications regards radiological/nuclear accidents and emergency exposure situation

ICRP Publication 40, 82, 96,109, 111, 124, 146

+ 1990 and 2007 Recommendations

Radiological Attack and Large Nuclear Accident are mainly focused on
Protective measures are advised in each phase (early, intermediate and long-term)
Protection of responders, people and the environment
Introduction of reference level

- Present activity of ICRP task group

Task group 120 Radiological Protection for Radiation Emergencies and Malicious Events

Updating and broadening the scope of Publication 96 to include a wide range of radiation emergencies that are not large-scale nuclear accidents.

- Advice for the Public on Protection in Case of a Nuclear Detonation

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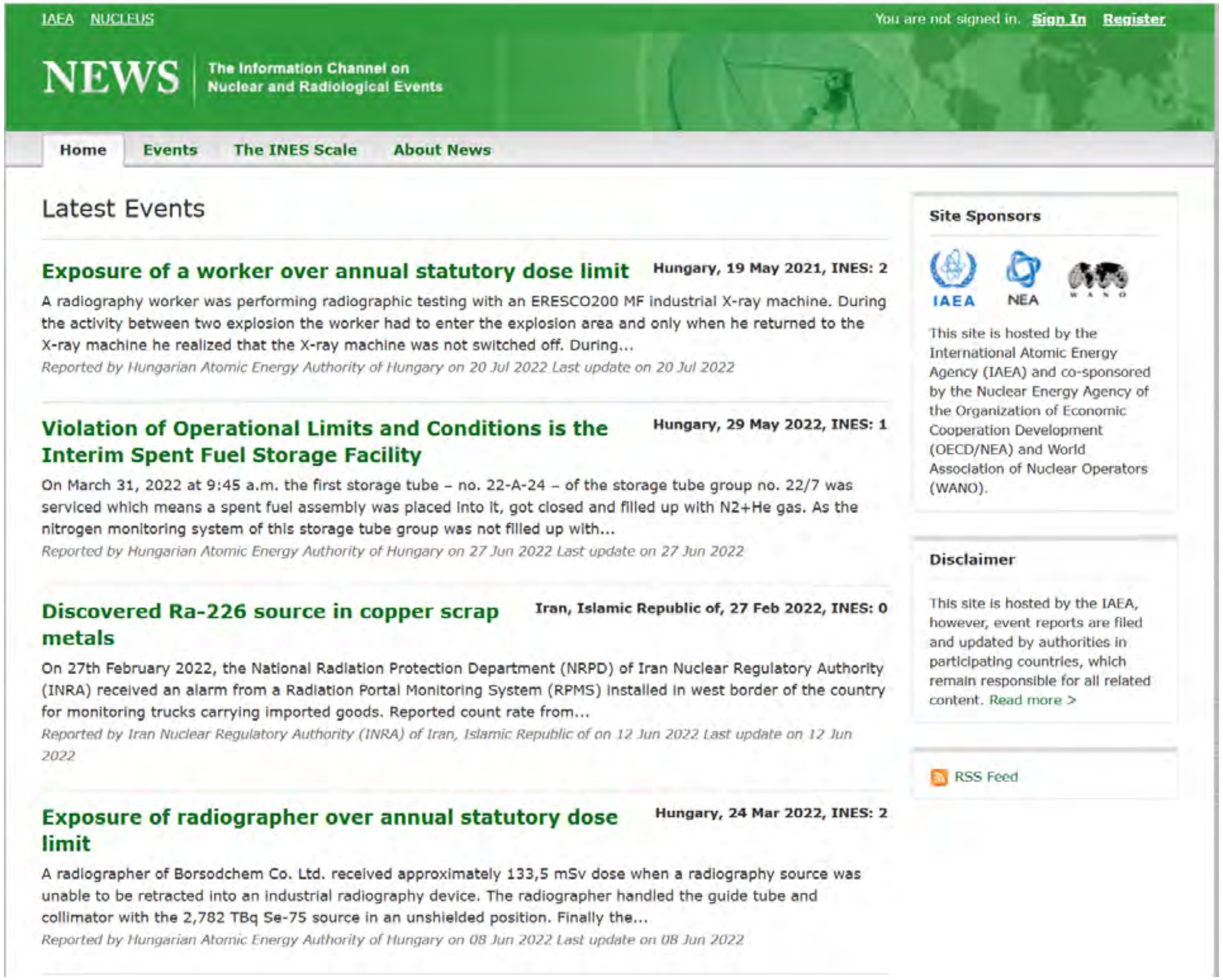
# Database for nuclear/radiological accidents

## IAEA NEWS(Nuclear Events Web-based System)



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NEWS The Information Channel on Nuclear and Radiological Events

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Latest Events

**Exposure of a worker over annual statutory dose limit** — Hungary, 19 May 2021, INES: 2

A radiography worker was performing radiographic testing with an ERESCO200 MF industrial X-ray machine. During the activity between two explosion the worker had to enter the explosion area and only when he returned to the X-ray machine he realized that the X-ray machine was not switched off. During...

*Reported by Hungarian Atomic Energy Authority of Hungary on 20 Jul 2022 Last update on 20 Jul 2022*

**Violation of Operational Limits and Conditions is the Interim Spent Fuel Storage Facility** — Hungary, 29 May 2022, INES: 1

On March 31, 2022 at 9:45 a.m. the first storage tube – no. 22-A-24 – of the storage tube group no. 22/7 was serviced which means a spent fuel assembly was placed into it, got closed and filled up with N2+He gas. As the nitrogen monitoring system of this storage tube group was not filled up with...

*Reported by Hungarian Atomic Energy Authority of Hungary on 27 Jun 2022 Last update on 27 Jun 2022*

**Discovered Ra-226 source in copper scrap metals** — Iran, Islamic Republic of, 27 Feb 2022, INES: 0

On 27th February 2022, the National Radiation Protection Department (NRPD) of Iran Nuclear Regulatory Authority (INRA) received an alarm from a Radiation Portal Monitoring System (RPMS) installed in west border of the country for monitoring trucks carrying imported goods. Reported count rate from...

*Reported by Iran Nuclear Regulatory Authority (INRA) of Iran, Islamic Republic of on 12 Jun 2022 Last update on 12 Jun 2022*

**Exposure of radiographer over annual statutory dose limit** — Hungary, 24 Mar 2022, INES: 2

A radiographer of Borsodchem Co. Ltd. received approximately 133,5 mSv dose when a radiography source was unable to be retracted into an industrial radiography device. The radiographer handled the guide tube and collimator with the 2,782 TBq Se-75 source in an unshielded position. Finally the...

*Reported by Hungarian Atomic Energy Authority of Hungary on 08 Jun 2022 Last update on 08 Jun 2022*

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INES scale 2 or higher incidents are required to be reported.

- Radiation exposure of workers exceeding annual dose limits
- Public exposure exceeding an effective dose of 10 mSv

https://www-news.iaea.org/ access on 29th Aug 2022

# Recent incident involved in $^{192}$Ir source

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## Worker Exceeded Annual Whole Body Dose Limit

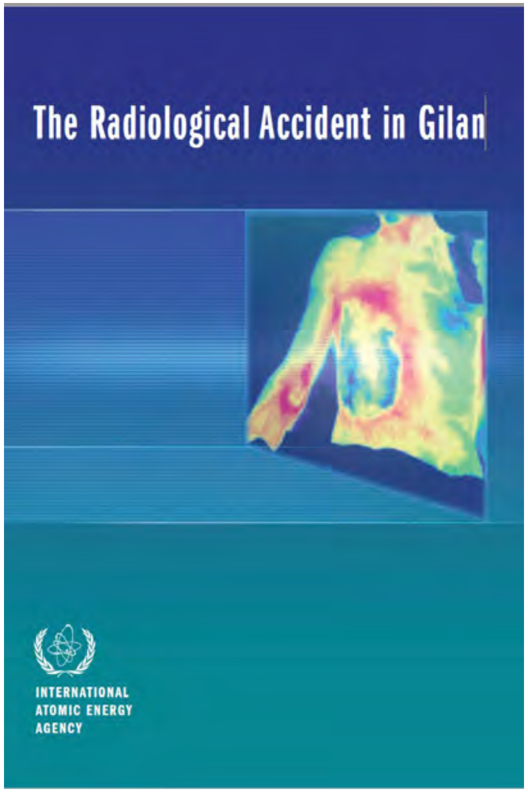
Posted on: 21 October 2021 Print View

| | | | |
|---|---|---|---|
| Event Date: | **06 October 2021** | Event Type: | **Radiation Source** |
| Event Location: | **United States of America, Pittsburgh, PA / Diamond Technical Services** | INES Rating: | **2 (Final)** |

A radiographer received approximately 0.093 Sv (9.3 rem) when a radiography source was unable to be retracted into an industrial radiography device. The radiographer handled the guide tube and collimator with the 3.367 TBq (91 Ci) Ir-192 source in an unshielded position. Dose reconstruction and event re-enactments were conducted to determine how the disconnect occurred. The cause of the event is believed to be a bent pin on the control cable. The licensee is performing testing and other actions to verify that this is the cause. After the radiographer retreated from the source, a Radiation Safety Officer with source retrieval authorization was dispatched to the location and recovered the source. Neither the Radiation Safety Officer nor the assistant radiographer received doses that exceeded the regulatory limit. The licensee committed to the mandatory re-training of employees. The dose to the radiographer exceeded the U.S. regulatory limit for the annual whole body dose of 0.05 Sv (5 rem).
NRC EN55511

https://www-news.iaea.org/ErfView.aspx?mId=eaeb776c-e350-4185-adf2-e930b44abe06

On 24 July 1996, a serious radiological accident happened at the combined cycle fossil fuel power plant in Gilan, Islamic Republic of Iran. The worker picked up the $^{192}$Ir sealed gamma ray source (185 GBq) and put it in his right pocket for approximately 1.5 hours.


[1] The radiological accident in Gilan. — Vienna : International Atomic Energy Agency, 2002

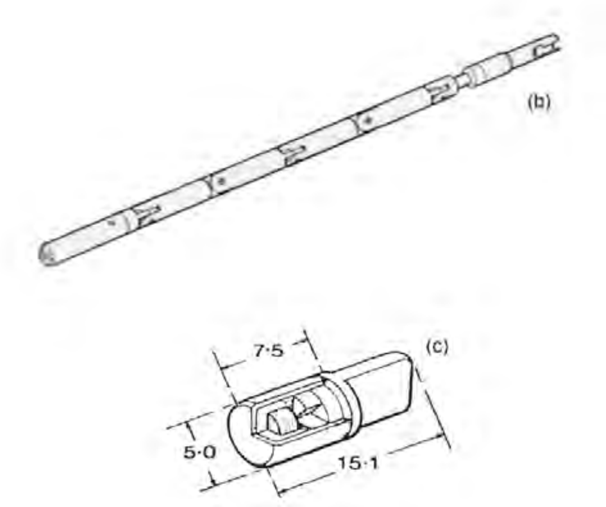
# Exposure situation

At around 03:00 on 24 July 1996, the iridium source became detached from its drive cable, reportedly due to failure of the lock on the radiography container. This resulted in the source falling 6 m into a trench which was surrounded by a 1 m high wall made of concrete blocks.

As the source was shielded by the concrete, its loss was not detected by the radiography team when they finished work and workers assumed that it had been safely returned to its container, as usual.

Soon after starting work at 08:00 on 24 July 1996 (Day 1), he noticed a shiny metallic object (the 192Ir source) lying in the trench. He picked up the source and put it in the right breast pocket of his coveralls. Over the next 1.5 h, he reportedly removed the source from his pocket to inspect it and then returned it to the pocket on a number of occasions. At around 09:30 he started to experience dizziness, nausea, lethargy and a burning feeling in his chest.


Industrial radiography apparatus




$^{192}$Ir sealed source



[1] The radiological accident in Gilan. — Vienna : International Atomic Energy Agency, 2002.

# Dose estimation in terms of various methods

Whole body dose of the worker
3.0–4.0 Gy from prodromal symptoms
2.5–3.5 Gy form haematological approach
3.1–4.7 Gy from biological dosimetry

TABLE IV. CORRECTED DOSE ESTIMATES

| Days after irradiation | Mean dose ± 95% confidence interval (Gy) | Dolphin [30] corrected dose (Gy) | Dolphin [30] irradiated body fraction (%) | Qdr [32] corrected dose (Gy) |
|---|---|---|---|---|
| 6 | 3.3 ± 0.4 | 4.1 | ≈50 | 4.14 |
| 27 | 2.1 ± 0.4 | 4.6 | ≈50 | 3.5 |
| 62 | 1.7 ± 0.5 | 4.7 | ≈50 | 4.7 |
| 239 | 1.45 ± 0.3 | 2.8 | ≈50 | 3.13 |

*PHOTO 2. Dark erythema with dry desquamation starting at the nipple on Day 12.*

Estimation of organ doses by means of physical dosimetry was not made.

[1] The radiological accident in Gilan. — Vienna : International Atomic Energy Agency, 2002.

# PHYSICAL RECONSTRUCTION OF EXPOSURES

Source: $^{192}$Ir, 185 GBq (5 Ci)
Exposure time: 1.5 h
Estimated average whole-body dose: 2 Gy

## SCENARIO A: SOURCE IN A POCKET, IN CONTACT WITH SKIN

## SCENARIO B: SOURCE AT A DISTANCE OF 20 cm FROM THE SKIN

## SCENARIO C: MOVING SOURCE IN A LOOSE POCKET

“Exposure scenarios A and B seem to be rather unlikely. The most feasible scenario is that given in Section 4.4. However, even accepting scenario C, the nature of the consequences cannot be fully explained.”

[1] The radiological accident in Gilan. — Vienna : International Atomic Energy Agency, 2002.

# Benchmark calculation for verification

Calculation was performed in the same irradiation condition as ICRP 145 (2)

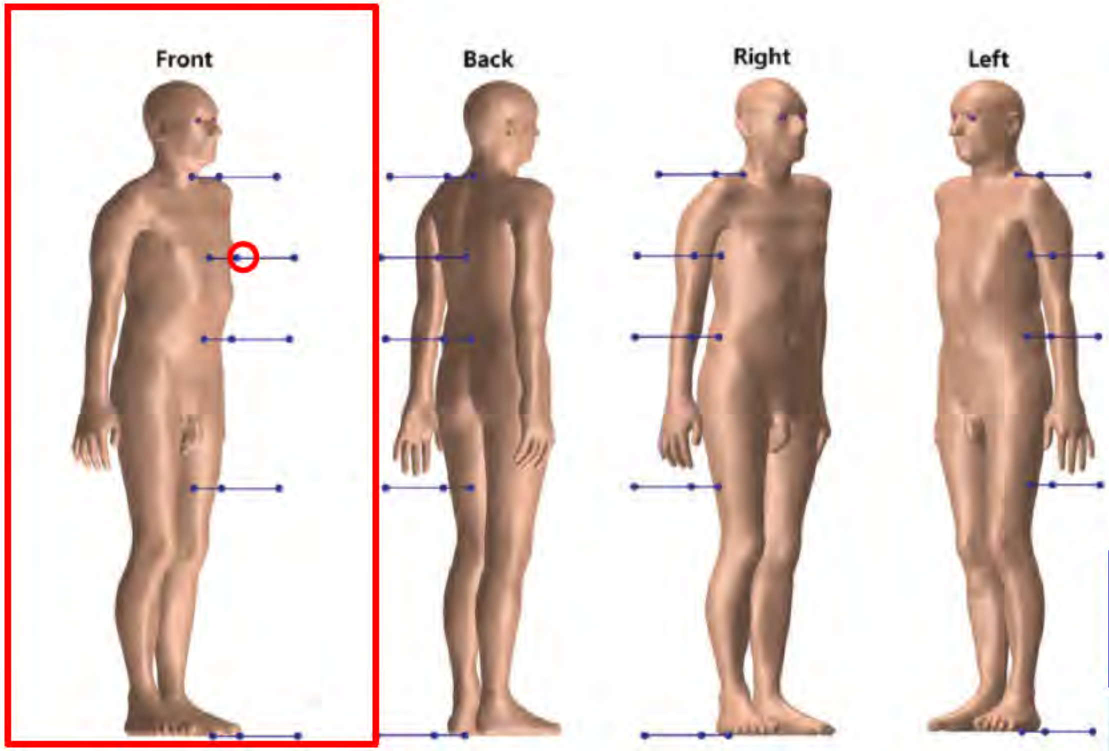



Fig. 8.2. Source locations at three distances (0.005, 0.1, and 0.3 m) at five levels (ground, middle thigh, lower torso, middle torso, and upper torso) in four directions (anterior, posterior, right lateral, and left lateral).

Point source positioned in the middle torso, 10 cm from the surface of the body

Comparison of dose coefficients of selected organs by the $^{192}Ir$ gamma ray ($\times 10^{-16}$ Gy $s^{-1}$ $Bq^{-1}$)

| | Lungs | Brain | Red bone marrow | Small intestine |
|---|---|---|---|---|
| ICRP Publ. 145 [5] | 4.76 | 0.714 | 2.11 | 2.94 |
| Calculated in this study | 4.79 | 0.693 | 1.93 | 3.14 |

agreed within 10%

> Our method was properly verified

[2] ICRP publication145

# Organ dose estimation of the accident

Organ doses in non-homogeneous exposure situations caused by a $^{192}$Ir sealed sources

| | Testis (Gy) | Lungs (Gy) | Brain (Gy) | Red bone marrow (Gy) | Small intestine (Gy) | Averaged whole body dose (Gy) |
|---|---|---|---|---|---|---|
| Scenario A* (point source) | **0.0058** | **1.0** | **0.089** | **0.29** | **0.19** | **0.31** |
| Scenario C* (Planer source) | **0.019** | **0.78** | **0.093** | **0.27** | **0.25** | **0.27** |

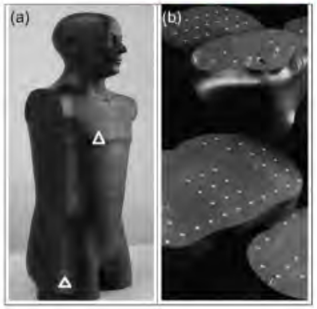
$^{192}$Ir 185 GBq sealed point source 90 min. exposure; only gamma ray accounted, NO encapsulation was considered.
Source distance (cm) ： almost contact to right chest surface
Calculated with PHITS 3.32 + ICRP Publ.145 AM-MRCP

**A point source** is located at a fixed position in the right chest pocket.

The point source in the right chest pocket is **assumed to be uniformly moved within a certain range.**

Results obtained from irradiation experiments using a RANDO phantom [3]

| | Testis (Gy) | Lungs (Gy) | Brain (Gy) | Red bone marrow (Gy) | Small intestine (Gy) | Averaged whole body dose (Gy) |
|---|---|---|---|---|---|---|
| Point source | **0.016** | **0.98** | **0.12** | **0.26** | **0.16** | **-** |



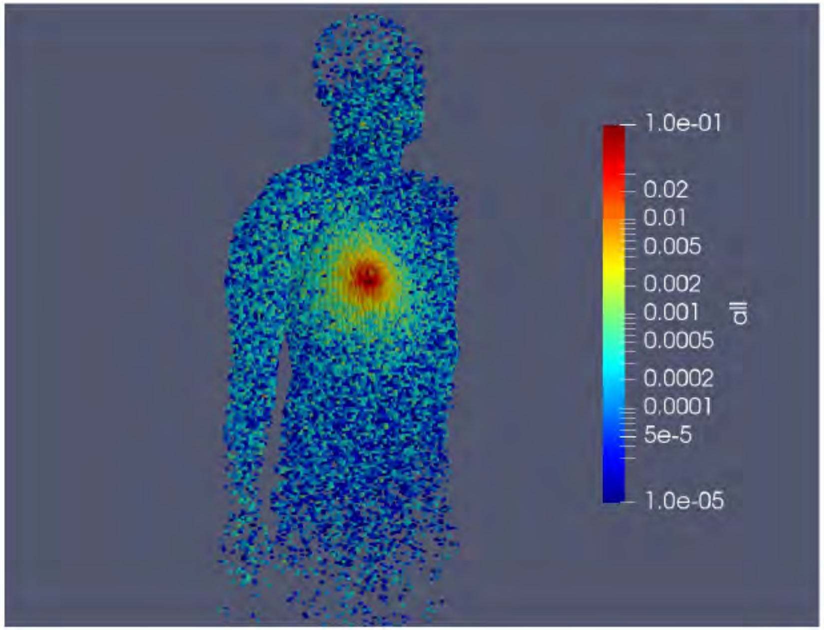



[3] V. Golikov, Radiation Protection Dosimetry (2019), Vol. 185, No. 1, pp. 75–81

# Skin dose and dose distribution

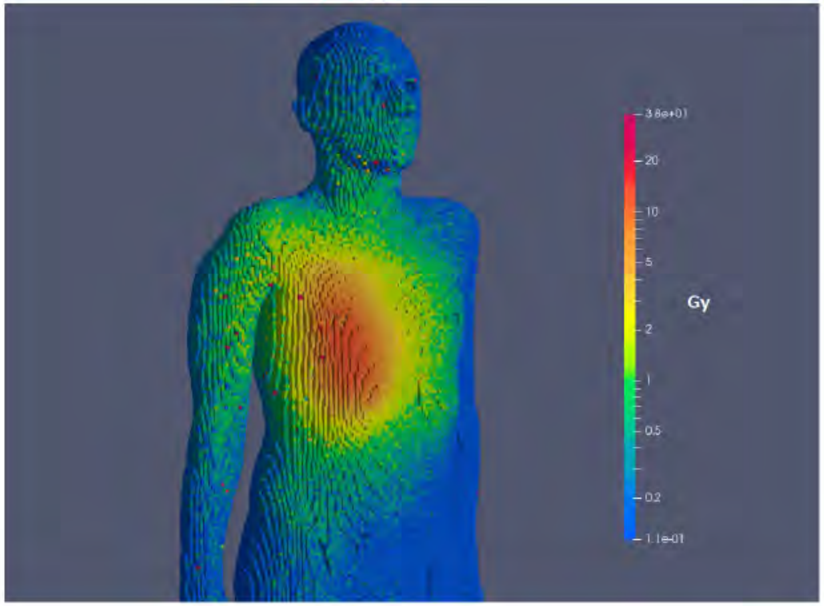
Scenario A

**A point source** is located at a fixed position in the right chest pocket.



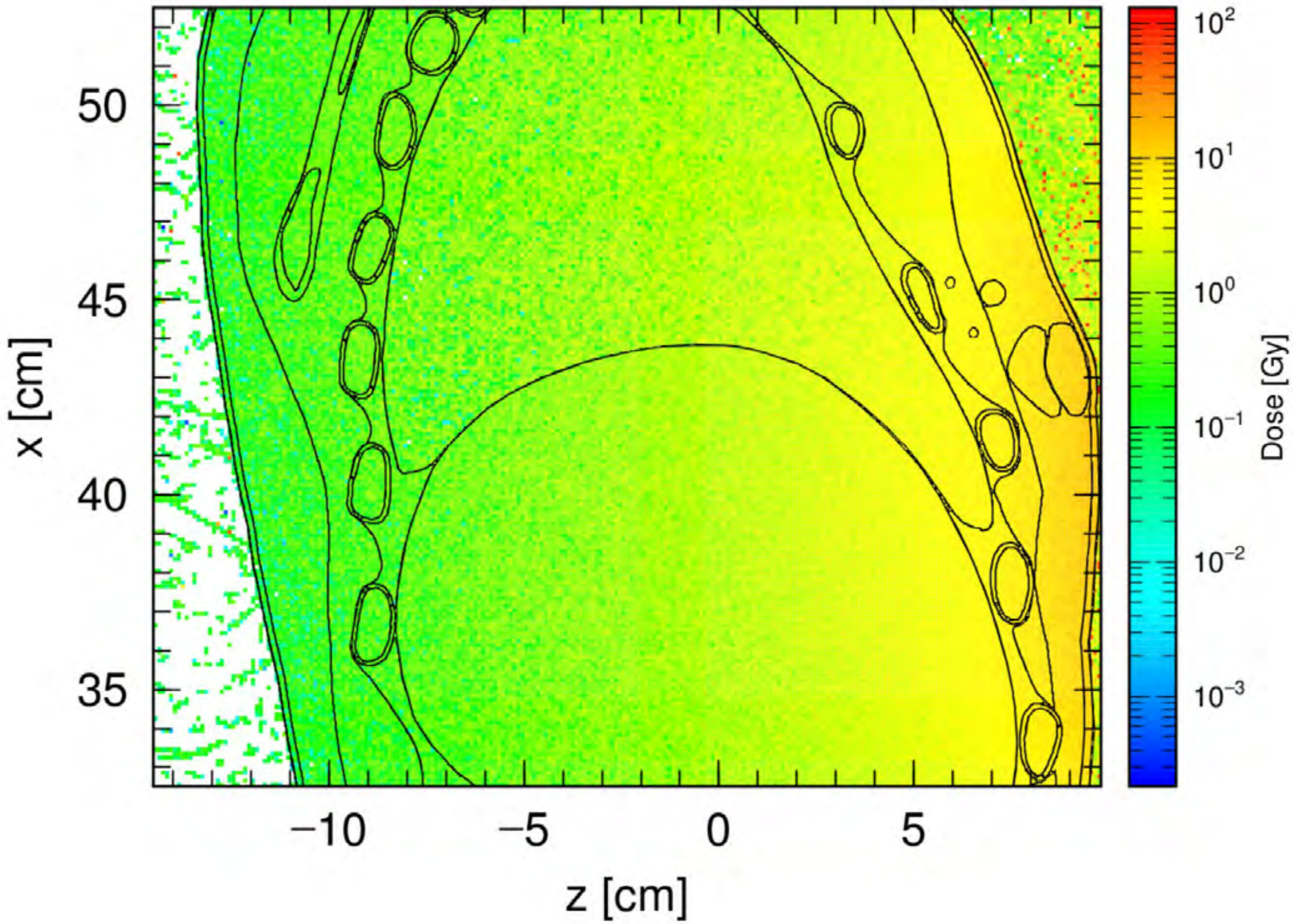

Scenario C

The point source in the right chest pocket is **assumed to be uniformly moved within a certain range.**



# Skin dose and dose distribution

Dose distribution in the right chest of the victim




Region where exposure over 1 Gy is about 10 cm from the body surface.
Skin dose could range between 10 and 30 Gy.

From the viewpoint of dose assessment for radiation emergency medicine:

- Organ doses were derived by Monte Carlo calculation to reproduce the exposure scenario
  > consistent with those experimentally obtained
  > dose distribution inside body were estimated

- MC calculation allows to introduce a complicated exposure scenario (a moving source in a pocket)

- averaged whole body absorbed dose were estimated to be 0.3 Gy.
  This has a large discrepancy between biological dosimetry (3 - 4 Gy)
  > similar tendency was observed in other accidents
  (for example, Peru, 2014)

# Example of dose reconstruction of victims

## Radiological accident in Peru, 2014
## (non-homogeneous exposure due to $^{192}$Ir source)


*FIG. 1. Worker 1 showing the manner in which he placed the guide tube with the collimator into his vest pocket (photographs courtesy of IPEN [6]).*


[4] The Radiological Accident in Ventanilla, INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 2019


TABLE 3. ESTIMATION OF THE WHOLE BODY DOSE FOR WORKER 1 [6]

| Joint | Action | Time (s) | Distance (cm) | Dose rate (mGy) | Dose (mGy) |
|---|---|---|---|---|---|
| Joint 20 | Changing film (2 × 20 s each) | 40 | 50 | 634.92 | 7.055 |
| | Taking radiographs (3 × 15 s each) | 45 | 1 000 | 1.59 | 0.020 |
| Joint 22 | Changing film (2 × 20 s each) | 40 | 50 | 634.92 | 7.055 |
| | Taking radiographs (3 × 15 s each) | 45 | 1 000 | 1.59 | 0.020 |
| Joint 24 | Changing film (2 × 20 s each) | 40 | 50 | 634.92 | 7.055 |
| | Taking radiographs (3 × 15 s each) | 45 | 1 200 | 1.10 | 0.014 |
| Joints 24–39 | Equipment and guide tube left on the ground | 20 | 10 | 15 873.00 | 88.183 |
| | Waiting for recovery equipment | 300 | 3 000 | 0.176 367 | 0.015 |
| | | | | Total | 109.415 (~ 0.1 Gy) |

TABLE 4. DOSE ESTIMATION BASED ON BIOLOGICAL DOSIMETRY (DICENTRIC ASSAY) [16, 19]

| Individual | Mean whole body dose (Gy) | Confidence interval 95% | Non-homogeneous whole body exposure | Laboratory |
|---|---|---|---|---|
| Worker 1 | 0.72 | [0.38–0.96] | Yes | ARN Argentina |
| Worker 1 | 0.76 | [0.51–1.06] | Yes | IRSN France |
| Worker 2 | 0.21 | [0.05–0.48] | Yes | IRSN France |
| Worker 3 | No detectable dose within the limits of sensitivity of the technique used (0.14 Gy for reference) | | | IRSN France |

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## Summary of the presentation (1)

- ICRP activities about nuclear/radiological accidents

- Publications regards radiological/nuclear accidents and emergency exposure situation

    ICRP Publication 40, 82, 96,109, 111, 124, 146

- Present activity of ICRP task group

    Task group 120 Radiological Protection for Radiation Emergencies and Malicious Events

- Advice for the Public on Protection in Case of a Nuclear Detonation

# Summary of the presentation (2)

- External dosimetry of victims who are accidentally exposed in non-homogeneous exposure accident

(1) Introducing the MC calculation by applying the state-of-the-art MRCP enables organ dose estimation in certain accuracy.

(2) MC calculation allows to reproduce a complicated exposure scenario, i.e., moving point source in the pocket.

# Thank you very much for your attention

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