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Radiological protection — Radiological monitoring for emergency workers and population following nuclear/radiological incidents — General principles

Radioprotection — Surveillance radiologique des intervenants en situation d'urgence et de la population après des incidents nucléaires/radiologiques — Principes généraux

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Foreword

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This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technology, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Nuclear accidents and major radiological events, referred to herein as nuclear or radiological incidents, can occur and may release large amounts of radioactive materials to the environment and affect large populations. Their consequences may differ across space and time and should be considered both at the emergency exposure situation and during long term recovery within the existing exposure situation. In these circumstances, screening, triage, monitoring and assessing radiation exposures for populations would be a key issue for managing the situation. More precise measurements and associated dose assessments need to be undertaken in support of, and according to, different objectives, including: identification of people potentially subject to internal/external contamination, health assessment, epidemiological follow-up, public information and reassurance and regulatory compliance. Furthermore, not only physical measurements but also biological estimation methods are useful for estimating exposures.

Radiological protection — Radiological monitoring for emergency workers and population following nuclear/ radiological incidents — General principles

1 Scope

This document presents general principles for preparedness to conduct individual contamination screening, triage, monitoring and assessing radiation doses received by people exposed during and/or in the aftermath of a nuclear or major radiological incident. The document mainly focuses on the early response phase, which requires rapid actions to be undertaken for achieving the goals in support of, and according to, national or international guidelines on emergency response.

It addresses general requirements for members of the public — this includes adults, vulnerable populations (such as children and pregnant women and people with special needs (such as the elderly and disabled) as well as emergency workers. This document provides general procedures for screening, triage and monitoring these two categories of people. It deals with individual monitoring for potential external contamination, internal and external exposures and dose assessment. It also gives principles for organizing and managing a population screening centre and for registering and reporting the results of individual monitoring. This document is applicable to most exposure situations following a nuclear or major radiological incident affecting a large number of people, including:

— significant release of radioactive materials (e.g. from a facility, transportation or nuclear power plant);

— radiological dispersal device (RDD);

— improvised nuclear device (IND);

— nuclear weapon.

Radiological incidents for which there is no release of radioactive substances in the environment but only external exposures (e.g. linked to a Radiation Exposure Device (RED)) are outside the scope of this document[1)]. However, some information given by this document may be of interest for this type of event.

The aim of document is to ensure that the appropriate parties are prepared in advance. This document advises how to obtain and collect data quickly and accurately in order to inform decision makers. It does not specify the parties or individuals who are responsible for undertaking the actions.

This document is intended to give guidance to those in charge of monitoring and assessing doses received by populations in emergency exposure situations involving a large number of people potentially subject to internal/external contamination (and subsequent radiation doses). It can also serve as guidance to regulatory bodies.

2 Normative references

There are no normative references in this document.

1) Incidents resulting from RED exposure are excluded from consideration in this document because they do not result in contamination that would be detected by a portal monitor or handheld device. Identification of victims with only potential external exposure are determined by means such as evaluation of clinical signs and symptoms, biodosimetry, EPR, etc.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
activity
A
quotient of –dN by dt, where dN is the change in the number of radioactive nuclei, at a particular energy state and at a given time, due to spontaneous nuclear transformations in the time interval dt

[SOURCE: ICRU 85, 6.2, October 2011, modified by changing the order of the phrases, by deleting the word “mean”, by adding the word “radioactive”.]

Note 1 to entry: It is expressed as $A = -dN/dt$. Activity can be calculated as $A = \lambda N$, where λ is the decay constant and N is the number of present radioactive nuclei.

Note 2 to entry: The special name for the unit of activity in the International System of Units is Becquerel (Bq), where 1 Bq = 1 s^{-1}, The use of the former unit Curie (1 Ci = 3,7 × 1 010 Bq), is also accepted in many countries and in BIPM.

3.2
contamination
radioactive substances on surfaces, or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable, or the process giving rise to their presence in such places

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.3
decontamination
complete or partial removal of *contamination* (3.2) by a deliberate physical, chemical or biological process

Note 1 to entry: This definition is intended to include a wide range of processes for removing contamination from people, equipment and buildings, but to exclude the removal of radionuclides from within the human body or the removal of radionuclides by natural weathering or migration processes, which are not considered to be decontamination.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.4
committed effective dose
$E(\tau)$
quantity $E(\tau)$, defined as:

$$E(\tau) = \sum_{T} w_T . H_T(\tau)$$

where $H_T(\tau)$ is the committed equivalent dose to tissue or organ T over the integration time τ elapsed after an intake of radioactive substances and w_T is the tissue weighting factor for tissue or organ T

Note 1 to entry: Where τ is not specified, it is taken to be 50 years for adults and the time to the age of 70 years for intakes by children. That is, for intakes by children, 70 years minus the age in years at exposure, for example, 60 years for a 10-year old child.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition, modified – by adding the last sentence of definition to Note 1 to entry]

3.5
exposure pathway
route by which radiation or radionuclides can reach humans and cause exposure

Note 1 to entry: An exposure pathway may be very simple, for example the external exposure pathway from airborne radionuclides, or a more complex chain, for example the internal exposure pathway from drinking milk from cows that ate grass contaminated with deposited radionuclides.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.6
absorbed dose
D
differential quotient of $\bar{\varepsilon}$ with respect to m, where $\bar{\varepsilon}$ is the mean energy imparted by ionizing radiation to matter of mass, *m*:

$$D = \frac{d\bar{\varepsilon}}{dm}$$

Note 1 to entry: The gray is a special name for joule per kilogram, and is to be used as the coherent SI unit for absorbed dose.

[SOURCE: ISO/IEC 80000-10, 10.81.1]

3.7
equivalent dose
H_T
quantity $H_{T,R}$, defined as:

$$H_{T,R} = w_R \cdot D_{T,R}$$

where $D_{T,R}$ is the *absorbed dose* (3.7) delivered by radiation type R averaged over a tissue or organ T and w_R is the radiation weighting factor for radiation type R

Note 1 to entry: When the radiation field is composed of different radiation types with different values of w_R, the equivalent dose is:

$$H_T = \sum_R w_R \cdot D_{T,R}$$

Note 2 to entry: The SI unit for equivalent dose is joule per kilogram (J.kg-1), termed the sievert (Sv).

Note 3 to entry: Equivalent dose is a measure of the dose to a tissue or organ designed to reflect the amount of harm caused.

Note 4 to entry: Equivalent dose cannot be used to quantify higher doses or to make decisions on the need for any medical treatment relating to deterministic effects.

Note 5 to entry: Values of equivalent dose to a specified tissue or organ from any type(s) of radiation can be compared directly.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.8
effective dose
E
quantity *E*, defined as a summation of the tissue or organ *equivalent doses* (3.7), each multiplied by the appropriate tissue weighting factor:

$$E = \sum_{T} w_T \cdot H_T$$

where H_T is the equivalent dose in tissue or organ T and w_T is the tissue weighting factor for tissue or organ T. From the definition of equivalent dose, it follows that:

$$E = \sum_{T} w_T \cdot \sum_{R} w_R \cdot D_{T,R}$$

where w_R is the radiation weighting factor for radiation type R and $D_{T,R}$ is the average *absorbed dose* (3.6) in the tissue or organ T delivered by radiation type R.

Note 1 to entry: The SI unit for effective dose is joule per kilogram ($J \cdot kg^{-1}$), termed the sievert (Sv).

Note 2 to entry: Effective dose is a measure of the dose designed to reflect the amount of radiation detriment likely to result from the dose.

Note 3 to entry: Effective dose cannot be used to quantify higher doses or to make decisions on the need for any medical treatment relating to deterministic effects.

Note 4 to entry: Values of effective dose from exposure for any type(s) of radiation and any mode(s) of exposure can be compared directly.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.9
tissue reaction
deterministic effect
injury in populations of cells, characterised by a threshold dose and an increase in the severity of the reaction as the dose is increased further

Note 1 to entry: In some cases, these effects are modifiable by post irradiation procedures including biological response modifiers.

[SOURCE: ICRP Publication 123]

3.10
erythema
reddening of the skin or mucous membrane

[SOURCE: ISO 10993-10:2021, 3.6]

3.11
tachycardia
increased heart rate due to exercise, pain, anxiety or pathophysiological state

[SOURCE: ISO 16972:2020, 4.42]

3.12
intake
<process> act or process of taking radionuclides into the body by inhalation or ingestion or through the skin

Note 1 to entry: Other exposure pathways by intake are injection (e.g. in nuclear medicine) and intake via a wound, as distinguished from intake through (intact) skin.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.13
intake
<quantity> activity of a radionuclide taken into the body in a given time period or as a result of a given event

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.14
kerma
K
for uncharged ionizing radiation, the differential quotient of E_{tr} with respect to m, where E_{tr} is the mean sum of the initial kinetic energies of all the charged ionizing particles liberated in a mass m of a material:

$$K = \frac{dE_{tr}}{dm}$$

[SOURCE: ISO 80000-10:2019, 86.1]

Note 1 to entry: It is expressed as $K = dE_{tr}/dm$

Note 2 to entry: The unit is J/kg. The special name for the unit of kerma is gray (Gy).

[SOURCE: ISO 12749-2:2022, 3.3.16]

3.15
exposure situation
circumstances of the exposure of the individual(s) to ionizing radiation sources

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.16
planned exposure situation
situation of exposure that arises from the planned operation of a source or from a planned activity that results in an exposure due to a source

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.17
event
any unintended occurrence, including operating error, equipment failure or other mishap, and deliberate action on the part of others, the consequences or potential consequences of which are not negligible from the point of view of protection and safety

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition. modified-By deleting the phrase “by the operator” and “nuclear”.]

3.18
emergency exposure situation
situation of exposure that arises as a result of an accident, a malicious act or other unexpected event, and requires prompt action in order to avoid or to reduce adverse consequences

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.19
existing exposure situation
exposure situation (3.15) which already exists when a decision on the need for control needs to be taken

Note 1 to entry: Exposure to background radiation and exposure to residual radioactive material from a nuclear or radiological emergency after the emergency exposure situation has been declared ended.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.20
reference level
<*emergency exposure situation* (3.18) or an *existing exposure situation* (3.19)> level of dose, risk or activity concentration above which it is not appropriate to plan to allow exposures to occur and below which optimization of protection and safety would continue to be implemented

Note 1 to entry: The value chosen for a reference level depends upon the prevailing circumstances for the exposure under consideration.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.21
dose assessment
assessment of the dose(s) to an individual or group of people

Note 1 to entry: For example, assessment of the dose received or committed by an individual on the basis of results from workplace monitoring or bioassay.

[SOURCE: IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.22
biomarker
traceable substance indicating changes in a cell or an organ caused by environmental actions (e.g. by ionizing radiation)

[SOURCE: ICRP Publication 123]

3.23
biodosimetry
biological dosimetry
assessment of the *absorbed dose* (3.6) of ionizing radiation using indicators found in biological material

3.24
in vitro measurement
analysis that include measurements of radioactivity present in biological samples taken from an individual

3.25
in vivo measurement
measurement of radioactivity present in the human body carried out using detectors to measure the radiation emitted

Note 1 to entry: Normally, the measurement devices are whole-body or partial-body (e.g. lung, thyroid) counters.

3.26
direct measurement
equipment for the determination of the body burden activity