



International
Standard

ISO 24434

**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*

**First edition
2024-01**

Reference number
ISO 24434:2024(en)

Full document details: [ISO 24434-2024](#)

© ISO 2024  **Documents**
Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© ISO 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO 2024 – All rights reserved

Contents

Page

Foreword	vi
Introduction	vii
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 Symbols and abbreviated terms	10
4.1 Symbols	10
4.2 Abbreviated terms	11
5 Collecting Information about the incident	12
5.1 General	12
5.2 Description of the incident	12
5.3 Source term identification and magnitude	13
5.4 Weather conditions and modelling results	13
5.5 Potential exposure pathways	14
5.6 Affected population and demographic information	14
6 Organizing and managing a population screening centre	14
6.1 Selecting the site	14
6.1.1 General considerations	14
6.2 Staffing and organization	16
6.2.1 General	16
6.2.2 Modules of a population screening centre	17
6.3 Scalability and sustainability	18
6.4 Practical considerations	18
6.5 Population with special needs	19
6.5.1 Main considerations	19
6.5.2 Other considerations	19
6.6 Services (medical and psychological, security and safety, communication, transportation)	19
6.6.1 Medical	19
6.6.2 Mental health (psychosocial)	20
6.6.3 Security and safety	20
7 Screening and monitoring for potential external contamination	21
7.1 Purpose	21
7.2 Radiation detection equipment	21
7.3 Contamination screening during initial sorting	22
7.4 Contamination screening station	22
7.4.1 General	22
7.4.2 Contamination screening station location	22
7.4.3 Contamination screening station staffing	22
7.4.4 Contamination screening station personal protective equipment (PPE)	22
7.5 Decontamination station	23
7.5.1 General	23
7.5.2 Decontamination station location	23
7.5.3 Decontamination station staffing ^[5]	23
7.5.4 Decontamination station personal protective equipment	23
7.5.5 Clothing and personal belongings	23
7.5.6 Partial-body decontamination	24
7.6 Post-decontamination screening	24
7.6.1 General	24
7.6.2 Factors affecting the criteria for determining if decontamination is warranted	24
8 Assessing and monitoring internal exposure	25
8.1 Overview	25

8.2	Sample collection.....	25
8.3	Monitoring for potential internal contamination.....	25
8.3.1	General.....	25
8.3.2	Monitoring for radionuclides emitting predominantly non-penetrating radiation.....	26
8.3.3	Penetrating radiation.....	27
8.3.4	Radionuclide mixture.....	27
8.4	Method for dose assessment.....	28
8.4.1	General.....	28
8.4.2	Initial dose assessment.....	29
8.4.3	Detailed internal dose assessment.....	30
9	Assessing and monitoring external exposure.....	30
9.1	General.....	30
9.2	Assessing external exposure.....	31
9.2.1	Subjects.....	31
9.2.2	Guidance.....	31
9.2.3	Measurement devices.....	31
9.3	Assessing external exposure for workers.....	33
9.3.1	Subjects.....	33
9.3.2	Procedure.....	33
9.3.3	Measurements.....	33
9.3.4	Calculations.....	34
9.3.5	Assessment.....	35
9.4	Assessing external exposure for emergency workers.....	36
9.4.1	Subjects.....	36
9.4.2	Guidance.....	36
9.4.3	Measurements.....	37
9.4.4	Calculations.....	37
9.4.5	Assessment.....	37
9.5	Assessing external exposure for the public.....	37
9.5.1	Subjects.....	37
9.5.2	Guidance.....	38
9.5.3	Measurements.....	38
9.5.4	Calculations.....	39
9.5.5	Assessment.....	40
9.6	Clinical and biological dose assessment.....	40
9.6.1	Overview.....	40
9.6.2	Clinical signs and symptoms.....	41
9.6.3	Haematology.....	41
9.6.4	Blood chemistry.....	42
9.6.5	Cytogenetics.....	42
9.6.6	EPR Dosimetry.....	44
9.6.7	Combination of dose assessment methods.....	45
10	Recording and reporting monitoring and dose assessment results.....	46
10.1	Purpose.....	46
10.2	Recording monitoring and dose assessment results.....	47
10.2.1	General.....	47
10.2.2	Recording screening and monitoring results.....	47
10.2.3	Recording dose assessment results.....	48
10.3	Reporting screening, monitoring and dose assessment results.....	48
10.3.1	General.....	48
10.3.2	Reporting results to the individuals being monitored and assessed.....	48
10.3.3	Reporting results to personnel performing more detailed dose assessment.....	49
10.3.4	Reporting results to professionals for medical or health follow up.....	49
11	Supporting processes and quality management.....	49
11.1	Purpose.....	49
11.2	Preparedness.....	50
11.3	Emergency plans and procedures (planning).....	50

11.4	Training and exercises.....	50
11.5	Communication.....	52
11.5.1	General.....	52
11.5.2	Public communication.....	52
11.5.3	Emergency operations communication.....	52
11.6	Audits and evaluation.....	53
Annex A (informative) Screening centre roles, equipment, and communication (see Clause 6).....		56
Annex B (informative) Screening external contamination.....		62
Annex C (informative) Sample biodosimetry and clinical worksheet.....		67
Annex D (informative) Grading system for response of neurovascular, gastrointestinal, Cutaneous, and hematopoietic systems.....		74
Annex E (informative) Examples of resources to assist responders and emergency medical personnel in managing radiation injury and dose assessment.....		76
Bibliography.....		78

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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), and
- 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 or nuclear power plant, during transportation);
- radiological dispersal device (RDD);
- improvised nuclear device (IND);
- nuclear weapon.

Radiological incidents for which there is no release of radioactive material in the environment but only external exposures (e.g. linked to a Radiation Exposure Device (RED)) are outside the scope of this document¹⁾. However, some information given by this document may be of interest for this type of event.

The aim of the 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.

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.

2 Normative references

There are no normative references in this document.

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 $1 \text{ Bq} = 1 \text{ s}^{-1}$. The use of the former unit Curie ($1 \text{ Ci} = 3,7 \times 10^{10} \text{ Bq}$), 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. 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. 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:

$$E(\tau) = \sum_T w_T \cdot H_T(\tau)$$

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 intakes by 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, for example, 60 years for a 10-year old child.

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

3.6

absorbed dose

D

differential quotient of $\bar{\epsilon}$ with respect to m , where $\bar{\epsilon}$ is the mean energy imparted by ionizing radiation to matter of mass, m :

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

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* (3.6) 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 ($J \cdot kg^{-1}$), 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. 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 ($\text{J}\cdot\text{kg}^{-1}$), 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. 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. 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. 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: The unit is $J \cdot kg^{-1}$. 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) or the environment to ionizing radiation sources

[SOURCE: ISO 12749-2:2022, 3.3.20]

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. 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. 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. 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. IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition]

3.20

reference level

level of dose, risk or activity concentration for an *emergency exposure situation* (3.18) or an *existing exposure situation* (3.19) 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. 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. 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, particularly peripheral blood

[SOURCE: ISO 12749-2:2022, 3.4.2]

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

3.27

screening

type of analysis aimed at eliminating from further consideration factors that are less significant for protection or safety, in order to concentrate on the more significant factors

3.28**monitoring**

measurement of dose, dose rate or activity for reasons relating to the assessment or control of exposure to radiation or exposure due to radioactive substances, and the interpretation of the results

Note 1 to entry: Monitoring may be subdivided in two different ways: 1) according to where the measurements are made, into *individual monitoring* (3.30), workplace monitoring, source monitoring and environmental monitoring, and, 2) according to the purpose of the monitoring, into routine monitoring, task related monitoring and special monitoring.

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

3.29**ambient dose equivalent**

$H^*(d)$

dose equivalent that would be produced by the corresponding aligned and expanded field in the ICRU sphere at a depth d on the radius vector opposing the direction of the aligned field

Note 1 to entry: The recommended value of d for strongly penetrating radiation is 10 mm.

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

3.30**individual monitoring**

personal monitoring

monitoring (3.28) using measurements by equipment worn by individuals, or measurements of quantities of radioactive substances in or on, or taken into, the bodies of individuals, or measurements of quantities of radioactive substances excreted from the body by individuals

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

3.31**personal dose equivalent**

$H_p(d)$

dose equivalent in soft tissue below a specified point on the body at an appropriate depth d

Note 1 to entry: Quantity used as a directly measurable proxy (i.e. substitute) for equivalent dose in tissues or organs or (with $d = 10$ mm) for effective dose, in *individual monitoring* (3.30) of external exposure.

Note 2 to entry: The recommended values of d are 10 mm for strongly penetrating radiation and 0,07 mm for weakly penetrating radiation.

Note 3 to entry: $H_p(0,07)$ is used for monitoring for hands and feet for all radiation types.

Note 4 to entry: $H_p(3)$ is used for monitoring exposure of the lens of the eye.

Note 5 to entry: 'Soft tissue' is commonly interpreted as the ICRU sphere.

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

3.32**quality assurance**

planned and systematic actions necessary to provide adequate confidence that a process, measurement, or service satisfy given requirements for quality such as those specified in a license

3.33**personal protective equipment****PPE**

equipment including clothing or other special equipment that is issued to individual workers to provide protection against actual or potential exposure to radioactive contaminants and ionizing radiations

Note 1 to entry: Includes partial or full-face respirators, face masks, gloves, safety glasses, boots, whole body anti-contamination coveralls, and self-contained breathing apparatus (SCBA), leaded overall, depending on conditions.

3.34**source term**

amount and isotopic composition of radioactive material released (or postulated to be released)

Note 1 to entry: Used in modelling releases of radionuclides to the environment, in particular in the context of accidents at nuclear installations.

[SOURCE: IAEA. IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition, modified-By deleting “from a facility” from the definition and “or releases from radioactive waste in repositories” from Note 1 to entry.]

3.35**incident**

any unintended event, including operating errors, equipment failures, initiating events, accident, precursors, near misses or other mishaps, or unauthorized act, malicious or non-malicious, the consequences or potential consequences of which are not negligible from the point of view of protection and safety

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

3.36**accident**

any unintended event, including operating errors, equipment failures and other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection and safety

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

3.37**emergency**

non-routine situation or *event* (3.17) that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human life and health, property and the environment

Note 1 to entry: This includes nuclear and radiological emergencies and conventional emergencies such as fires, release of hazardous chemicals, storms or earthquakes.

Note 2 to entry: This includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.

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

3.38**nuclear or radiological emergency**

nuclear or radiological incident *emergency* (3.37) in which there is, or is perceived to be, a hazard due to:

- a) the energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction, or
- b) radiation exposure

Note 1 to entry: Points (a) and (b) approximately represent nuclear or radiological emergencies (incidents), respectively. However, this is not an exact distinction.

Note 2 to entry: Radiation emergency is used in some cases when an explicit distinction in the nature of the hazard is immaterial (e.g. national radiation emergency plan), and it has essentially the same meaning.

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

3.39

emergency preparedness

capability to take actions that will effectively mitigate the consequences of an *emergency* (3.37) for human life, health, property and the environment

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

3.40

precautionary action zone

PAZ

area around a facility for which *emergency* (3.37) arrangements have been made to take urgent protective actions in the event of a *nuclear or radiological emergency* (3.38) to avoid or to minimize severe deterministic effects off the site

Note 1 to entry: Protective actions within this area are taken before or shortly after a release of radioactive material or an exposure, on the basis of prevailing conditions at the facility.

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

3.41

urgent protective action planning zone

UPZ

area around a facility for which arrangements have been made to take urgent protective actions in the event of a *nuclear or radiological emergency* (3.38) to avert doses off the site in accordance with international safety standards

Note 1 to entry: Protective actions within this area are to be taken on the basis of environmental monitoring or, as appropriate, prevailing conditions at the facility.

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

3.42

emergency response

performance of actions to mitigate the consequences of an *emergency* (3.37) for human life, health, property and the environment

Note 1 to entry: The emergency response also provides a basis for the resumption of normal social and economic activity.

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

3.43

emergency worker

person having specified duties as a worker in response to an *emergency* (3.37)

Note 1 to entry: Emergency workers may include workers employed, both directly and indirectly, by registrants and licensees, personnel of response organizations, such as police officers, firefighters, medical personnel, and drivers and crews of vehicles used for evacuation, as well as volunteers.

Note 2 to entry: Emergency workers may or may not be designated as such in advance of an emergency. Emergency workers not designated as such in advance of an emergency are not necessarily workers prior to the emergency, such as volunteers who willingly and voluntarily helps in the response to a nuclear or radiological emergency.

[SOURCE: IAEA. IAEA Safety Glossary Terminology used in Nuclear Safety and Radiation Protection – 2018 Edition, modified – by adding “, as well as volunteers.” to the end of Note 1 to entry and “, such as volunteers who willingly and voluntarily helps in the response to a nuclear or radiological emergency.” to the end of Note 2 to entry.]

3.44

first responder

first members of an emergency service to respond at the site of an *emergency* (3.37)

Note 1 to entry: These may include police, firefighters and rescue brigades, ambulance services, and control teams for hazardous materials.

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

3.45

improvised nuclear device

IND

device incorporating radioactive materials designed to result in the formation of a nuclear-yield reaction

Note 1 to entry: Such devices may be fabricated in a completely improvised manner or may be an improvised modification to a nuclear weapon.

[SOURCE: IAEA. IAEA Nuclear Security Glossary, August 2020]

3.46

radiological dispersal device

RDD

device to spread radioactive material using conventional explosives or other means, thereby exposing people and the environment to radiation

[SOURCE: IAEA. IAEA Nuclear Security Glossary, August 2020, modified- By adding the phrase “, thereby exposing people and the environment to radiation”.]

3.47

radiation exposure device

RED

device with radioactive material designed to intentionally expose members of the public to radiation

[SOURCE: IAEA. IAEA Nuclear Security Glossary, August 2020]

3.48

nuclear weapon

state-sponsored, designed, engineered, and tested weapon, tens to hundreds of times more powerful than INDs

4 Symbols and abbreviated terms

4.1 Symbols

A	activity (Bq)
$\langle A \rangle$	measured activities (Bq)
$E(\tau)$	committed effective dose received within τ years after an intake (Sv)
$e(\tau)$	coefficient of the committed effective dose received within τ years after an intake ($\text{Sv} \cdot \text{Bq}^{-1}$)
$H_T(\tau)$	committed equivalent dose to tissue/organ T received within τ years after an intake (Sv)

$h_T(\tau)$	coefficient of the committed equivalent dose to organ/region T received within τ years after an intake ($\text{Sv}\cdot\text{Bq}^{-1}$)
I	estimated value of a radionuclide intake (Bq)
M	measured quantity (Bq)
$m(t)$	bioassay function at a time t after intake ($\text{Bq}\cdot\text{Bq}^{-1}$)
Q	quality of the adjustment for a given mesh vertex
r_T	target region

4.2 Abbreviated terms

AMAD	activity median aerodynamic diameter
AP	antero-posterior
CDC	U.S. Centers for Disease Control and Prevention
PSC	population screening centre
DTPA	diethylenetriaminepentaacetic acid
EPA	U.S. Environmental Protection Agency
EPR	electron paramagnetic resonance
ESR	electron spin resonance
FISH	fluorescence in situ hybridization
GM	Geiger-Mueller
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
IND	improvised nuclear device
NaI	sodium iodide
NCRP	National Council on Radiation Protection and Measurements
OSLD	optically-stimulated luminescence dosimeter
PAZ	precautionary action zone
PPE	personal protective equipment
RBE	relative biological effectiveness
RED	radiological exposure device
RDD	radiological dispersal device
ROT	rotational

RPLD	radio photo-luminescence dosimeter
TLD	thermo-luminescence dosimeter
UPZ	urgent protective action planning zone

5 Collecting Information about the incident

5.1 General

In order to assist with the identification of individuals that need attention and to determine what type of monitoring, assessment, and mitigation methodologies, such as decontamination and countermeasures²⁾, may be required, the responsible authority shall have in place a system for recording the following types of information:

- type of radiation incident;
- source term;
- weather conditions and modelling results;
- timing (duration) and magnitude of release;
- potential exposure pathways;
- affected populations and demographic information.

Each is described in detail.

5.2 Description of the incident

In order to understand the potential radionuclides present, the extent of dispersal and the emergency response actions that may be performed, provision shall be made to record the type of nuclear incident responsible for the emergency.

The types of nuclear or radiological incidents can be grouped into the following categories:

- accidental release of radioactive materials (e.g. from a facility, transportation or nuclear power plant);
- radiological dispersal device (RDD);
- improvised nuclear device (IND);
- strategic nuclear weapon;
- nuclear weapon;
- radiation exposure device (RED).

Information can be obtained from response of active monitors such as continuous air monitors or radiation area monitors, video from passive security cameras or active recording of operations, behaviour of the released radioactivity, interviews of witnesses, and symptoms manifested by individuals as reported by hospitals or other emergency treatment facilities. A timeline of activities and response actions can be helpful in identification of release parameters and exposure cohorts, groups of individuals requiring similar monitoring, assessment, and treatment due to the characteristics of the exposures, as well as add to the accuracy of modelling.

2) See *Radiation Countermeasures for Treatment of Internal Radiation Contamination*, <https://remm.hhs.gov/int-contamination.htm#blockingagents>.

5.3 Source term identification and magnitude

The most urgent and important data to collect is the identification of the radionuclide and amount released. The first and best source of this information is from the type of radiological dispersal and, in the case of an accidental release, facility and operator from which a release or dispersion has occurred. This should be confirmed by measurement.

If this information is not available, other measurements and observations shall be made. Spectrometric measurements can be made using appropriate instrumentation to determine the radionuclide(s). Depending on the release scenario, types of samples collected could include:

- airborne particulates;
- airborne gas;
- water;
- soil;
- other materials.

Chemical and physical form are more difficult to determine and may require repetitive measurements to determine environmental migration, systemic metabolism, or other behaviour of the source material including the use of scanning electron microscopy, radiochemical methods, or other more accurate or precise measurement technique.

The magnitude of the release shall also be determined. In the case of RDDs, the simplest way of making a determination may be to identify the amount of missing mass or activity. This can be accomplished with prior knowledge either of the mass or radioactivity of the material in question followed by mass or activity measurement of the remaining material and determining the difference.

If prior knowledge of the amount of material is not available, the determination is more difficult. This likely requires an iterative process of modelling the incident with an assumed or estimated amount of radioactivity released and using environmental measurements to adjust the released radioactivity estimate upwards or downwards. Such an analysis certainly has increased uncertainty over the mass-difference methodology described above.

5.4 Weather conditions and modelling results

Soon after a release of radioactive material to the environment, it is desired to obtain an estimate for the extent of any airborne or surface contamination, both for identification of affected individuals and to begin identification of recovery activities. Various computer software codes exist in order to perform this type of analysis at varying levels of complexity and associated computer run times.

Important inputs to such codes are weather conditions including wind direction and rainfall and:

- mean wind speed at pollutant release height, $\text{m}\cdot\text{s}^{-1}$;
- emission rate, $\mu\text{g s}^{-1}$ or Bq s^{-1} ;
- standard deviation of lateral concentration distribution;
- standard deviation of vertical concentration distribution;
- pollutant release height (stack height), m;
- crosswind distance from source to receptor, m.

Full soundings that include wind speeds and directions at different elevations can also be used.

5.5 Potential exposure pathways

When the information described is collected, potential exposure pathways may be identified. Such pathways are important for the determination of dosimetry analysis that can be used to estimate risk to exposed individuals. Common initial exposure pathways include:

- inhalation/ingestion of airborne activity from suspended release;
- inhalation/ingestion of airborne activity re-suspended from ground deposition;
- ingestion of contaminated food and drink items
- external dose from suspended release;
- external dose from ground deposition;
- skin contamination from transfer of ground or surface contamination or suspended material;
- intake via wound or absorption through intact skin (iodine and tritium).

As the incident continues, additional pathways become important, such as intake through ingestion of foodstuffs.

5.6 Affected population and demographic information

The size and demographics of the potentially affected population is used in determining the selection of the population screening centre (PSC) site (see [Clause 6](#)) and the resources needed for timely screening and decontamination. Special considerations may include:

- number of people, pets, etc. in contaminated area;
- population density;
- zoning (residential, industrial, offices);
- types of buildings (housing units, apartments, multi-level structures);
- populations with special needs (refer to [6.5](#));
- cultural, religious, language factors.

6 Organizing and managing a population screening centre

6.1 Selecting the site

6.1.1 General considerations

One important benefit of planning in advance for the establishment of population screening centres (sometimes referred to as Community Reception Centres) is that it reduces the potential burden on hospitals by providing a location for non-injured people to be screened for contamination. Another benefit is that it supports the operations of public and special needs shelters that host the displaced population.

The considerations listed in this subclause ensure that the population screening centre is able to meet the needs of the impacted community following a nuclear or radiological incident.

- Identify multiple locations: Planners should consider several locations for conducting population screening and decontamination, due to the uncertainties of where the incident may take place and the likelihood that any of the pre-selected sites would be inaccessible during an emergency.
- Consider collocating with other facilities: To best support shelter operations, planners should consider establishing one or more population screening centres at or near shelters hosting displaced population.

- Allow for flexibility: For large incidents, planners may establish a network of population screening centres that feeds into a larger network of ad-hoc screening locations, shelters, and hospitals, as diagrammed in [Figure 1](#).

Recommendations for identifying and selecting facilities:

- a) If possible, establish the population screening centres at locations in areas that ambient dose rate is less than predefined level.
- b) Identify facilities based on the anticipated number of affected population and estimated throughput. Consider facilities that are large enough to contain all necessary functions described in this Clause.
- c) If possible, select an all-weather facility designed for crowds (with environmental control to prevent temperature extremes).
- d) Ensure availability of entrance and exit control.
- e) Ensure facility is suitable for accommodating vulnerable populations and people with disabilities.
- f) Ensure availability of facilities for decontamination, e.g. sinks/showers, or plan for alternate ways of decontaminating people such as using wet wipes.
- g) Ensure adequate parking is available for people arriving in their own vehicles and larger spaces for parking buses.
- h) Select locations that are easily accessible.

Examples of suitable facilities include: a covered sports arena or convention centre, schools with gymnasiums, etc. Depending on the circumstances and weather, a tent in a nearby park or large parking lot would also suffice.

NOTE It is important to establish use agreements in advance with facility or site owners and operators.

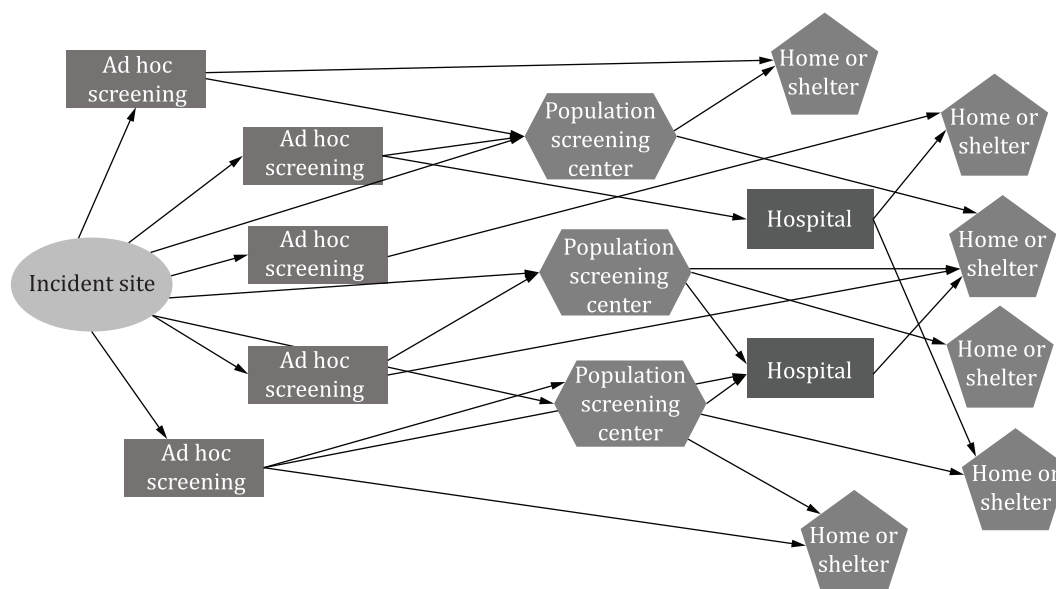


Figure 1 — Schematic of a network of population screening centres including ad hoc screening, hospitals and shelters

6.2 Staffing and organization

6.2.1 General

The site should have sufficient staff, both technical and non-technical, to operate the various stations and manage the screening centre for up to several days or weeks. A technical staff competent in the use of radiation detection equipment shall be available to support contamination screening. The qualified staff available to operate the facility should include personnel assigned to screen people for contamination, help with decontamination, registration, etc. At least one or more nurses or clinicians shall be readily available to assess and refer people who need medical follow-up. Additional modules may be added to collect spot urine samples for bioassay, accommodate pets, as needed. Plans should exist to bring in additional personnel and assets to allow initial staff to rotate.

A modular population screening centre is shown in [Figure 2](#). It contains eight modules/stations, each described further in this subclause. This modular approach allows for scalability and flexibility according to the demands of the incident and the availability of resources. Additional modules may be added to accommodate pets, bioassay, or other stations, as needed.

A clear demarcation between the contamination control zone and the clean zone shall exist and these two zones should be clearly identified. [Table 1](#) provides an example of where the various stations should be located with respect to the contamination control zone.

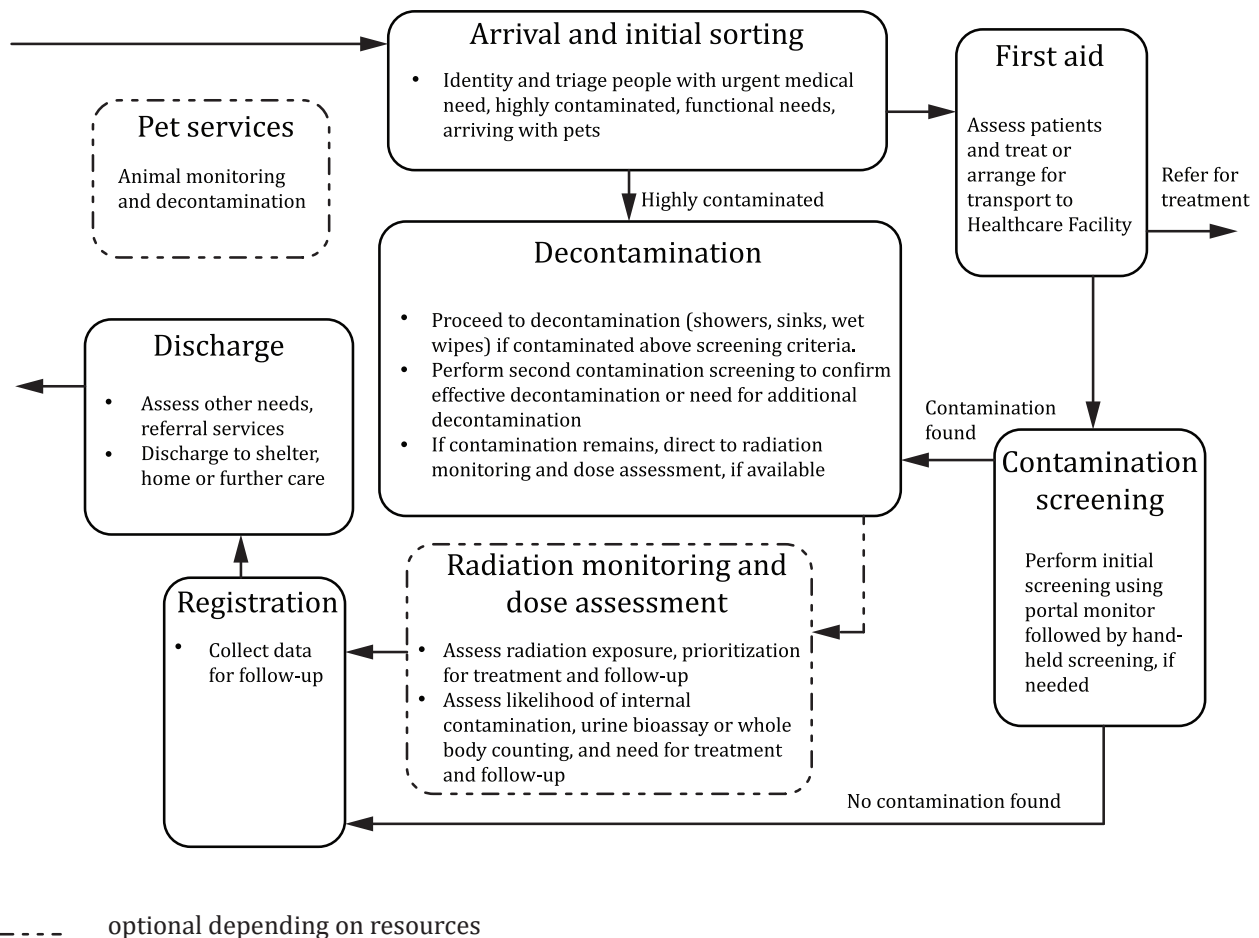


Figure 2 — Example of a population screening centre modular design

NOTE The type of isotope(s) involved is determined in the field by environmental measurements and that information is available to the population screening centres (for setting up their screening equipment).

Table 1 — Locations of population screening centre stations with respect to the contamination control zone

Station	Zone
Initial sorting First aid Contamination screening Decontamination Pet services (if available)	Contamination control zone
Registration Radiation monitoring and dose assessment Discharge	Clean zone

6.2.2 Modules of a population screening centre

Example stations at the population screening centre illustrated in [Figure 2](#) may include:

- initial sorting;
- first aid;
- contamination screening;
- decontamination;
- pet services (for pet-friendly centres);
- registration;
- radiation monitoring and dose assessment;
- discharge.

[Annex A](#) provides a brief description of each station. An example of floor plan depicting the location of the various stations is shown as [Figure 3](#).

In addition to staffing these stations, the screening centre should include a site manager, health and safety officer, and security. It should also consider including additional staff to assist or direct people while they are going from station to station.

Additional staff may be needed to select those individuals waiting in line by questioning when arriving who may have high contamination or need special assistance such as:

- families with small children;
- unaccompanied minors;
- people who might have medical problems;
- women who might be pregnant;
- people who do not speak or understand the language spoken;
- people with cultural or religious considerations.

Provisions to have mental health professionals available, and possibly a station for providing or directing people to counselling resources should also be considered.

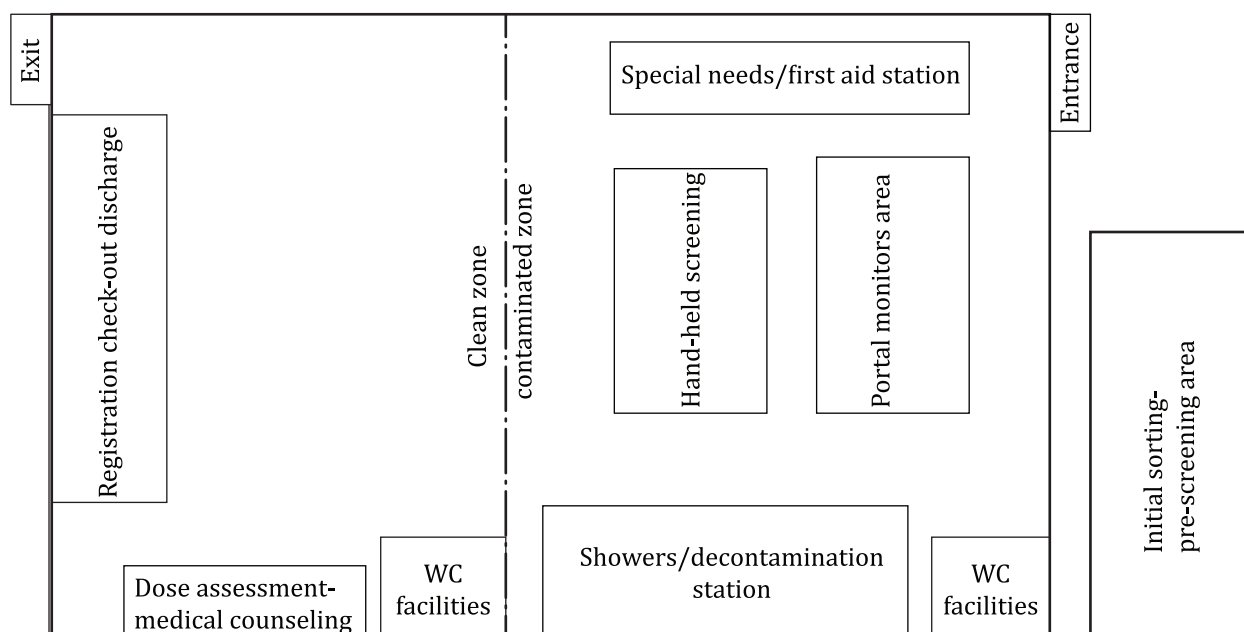


Figure 3 — Example of a population screening centre floorplan

6.3 Scalability and sustainability

The size and nature of the incident are major considerations in planning for population screening. Population screening plans should be scalable based on the timeframe (hours, days, weeks since the incident), the geographical factors (urban, rural, spread of contamination), distance from impacted area, the population affected (size, demographics), available equipment and facilities (for screening and decontamination) and the desired throughput of the screening centre (how many people to process over a given time). If a few hundred people need to be surveyed and decontaminated, emergency workers can probably provide very thorough services at the scene. However, if thousands of people are affected, screening centre operators shall have the flexibility to scale or modify operations as necessary, so that everyone is processed quickly and safely.

6.4 Practical considerations

- Display a schematic of the *screening centre* to help people navigate the site and include easy-to-read-signs to indicate station name and direction to the next station.
- Consider including signs and infographics, in particular as people are directed to the decontamination station (this helps people that have limited reading skills or do not speak the language).
- Consider having translators.
- Provide a map indicating the affected area so people can point to where they were at the time of the incident. This information is useful for pre-identifying people in higher exposure/contamination areas.
- Consider including one or two clinicians to assist with medical questions.
- Consider including mental health professionals.
- Plan how the data are collected— paper forms, electronic, hybrid.
- Consider locating population screening centre away from the affected area and near shelter location and other centres that may be assisting, such as family reunification, housing assistance, etc.

6.5 Population with special needs

6.5.1 Main considerations

Public health authorities and emergency planners should identify and prioritize populations in the community that are vulnerable or have special needs during and after a nuclear or radiological incident. These include the following:

- children, as they may be at a higher risk of being contaminated with radioactive materials, receive higher doses per unit intake compared with adults, are more sensitive to radiation health effects and may suffer more significant psychosocial impacts than adults (be cognizant of minor children without custodial adults present, e.g. school children or unaccompanied minors; families should remain together);
- pregnant and nursing mothers;
- elderly people requiring assistance;
- immunocompromised individuals;
- disabled persons requiring the use of wheelchairs or other mobility aids;
- transient or migrant workers;
- commuters;
- homeless people;
- institutionalized individuals who may or may not be able to evacuate or relocate;
- hospitalized patients;
- residents of nursing homes or other institutions;
- prison inmates, guards.

Public health authorities and emergency planners should also address the needs of emergency workers.

6.5.2 Other considerations

- a) Determine any cultural or religious factors in the community that would affect the population screening process. For example, changing clothing in a public setting may present a complication for some people.
- b) Identify and develop relationships with organizations that are currently assisting special populations in or near the community. They may be able to assist.
- c) Ensure that communications and educational materials are available in appropriate languages and literacy level for the community. People who do not speak, as a first language, the official language in the country the incident has taken place could have great difficulty in understanding instructions when under the stress of a nuclear or radiological incident. Consider visuals, universal signage, or videos to communicate vital information.
- d) Determine if the screening centre accepts pets and, if so, how they are handled. Be aware that this may affect population screening.

6.6 Services (medical and psychological, security and safety, communication, transportation)

6.6.1 Medical

Even though the main purpose of the population screening centre is to screen ambulatory uninjured people, it is likely that some people present with minor injuries or may have a need for immediate medical care while at the population screening centre. This may be the case for those waiting in line for a long time, have

underlying medical conditions, are elderly, pregnant, etc., or have high levels of anxiety. In this situation, people should be directed to the first aid station where they can have access to a health care provider to treat minor injuries and/or arrange for transporting those requiring immediate medical attention to the hospital.

Other activities that would fall under this station may include:

- examining exposed and potentially contaminated persons for signs of injuries and potential life-threatening problems. This has priority over assessing contamination and decontamination,
- stabilizing life-threatening problems,
- observing for signs of psychological distress,
- examining exposed persons for signs of acute radiation exposure (Table 6.2 of NCRP 161-I describes early effects of whole-body irradiation from external and internal sources).

Dose assessment and reporting is presented in [9.6](#) and [Clause 10](#).

6.6.2 Mental health (psychosocial)

Psychosocial issues (among the affected population, as well as emergency workers and PSC staff) present significant challenges to public health and medical practitioners both during and after a radiation emergency. The psychosocial consequences of radiation emergencies are unique and serious, and in many ways can be even greater and longer lasting than the physical or economic consequences. People seeking assessment and care are likely to overwhelm public health and medical systems.

Many jurisdictions recognize that preparing to deal with psychosocial issues is critically important for efficiently managing and monitoring the affected population and engaging in other response efforts. Planners should include behavioural health and mental health specialists in emergency planning and response. Psychological first aid is a way to help reduce the initial distress caused by traumatic events. Emergency workers who interact with the public can benefit from training in psychological first aid. Emergency workers should anticipate normal stress reactions and promote the following principles of psychological first aid.

- Safety: provide repeated, simple, and accurate information on how to meet basic needs. This may be especially important for population screening centre staff wearing PPE that hinders communications (such as masks).
- Calm: speak calmly and be compassionate and friendly.
- Connectedness: keep families together.
- Self-efficacy: give practical suggestions to help empower people.
- Help: direct people to available services.

If possible, include behavioural health or mental health professionals on staff at each population screening centre. During the planning process, establish a contact list of credentialed personnel who could provide these services. Plans should also include providing counselling for staff and emergency workers. Adequate rotation of staff members to reduce physical and emotional fatigue is essential.

Public health and emergency preparedness authorities should plan to augment pre-existing behavioural health and mental health services. Such services are in demand both by people acutely affected by the nuclear or radiological incident as well as by members of the public with chronic, long-term mental health needs. The need for such services increases following a nuclear or radiological incident, whether it involves mass casualties or not.

6.6.3 Security and safety

Population screening centres shall include security and safety staff as part of their staffing plan. Security is crucial for running a smooth operation, since these centres will likely handle many people who may be waiting in line for extended periods, are likely anxious, tired, etc., and may become unruly or have malicious