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Protective actions in a nuclear or radiological emergency

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1. General

1.1 Contents

This guide concerns the protective actions in the early and intermediate phases of a nuclear or radiological emergency. The guide describes the content and rationale of the protective actions, including the dose criteria and indicative operational intervention levels, the actual or anticipated exceedance of which typically requires protective actions. The operational intervention levels set out in the guide are not absolute limit values but approximate magnitudes and indicative in nature. The guide applies to emergency exposure situations as defined in the Radiation Act (859/2018, Section 4).

This guide applies to both normal and exceptional conditions. A particularly serious major accident may also be the basis for exceptional conditions (Emergency Powers Act (1552/2011), Section 3(4)). Although exceptional conditions affect the authorities' powers of action, the radiation protection criteria for protective actions in exceptional conditions remain identical to those under normal conditions.

A nuclear or radiological emergency is an emergency exposure situation in which the consequences of an imminent or actual incident require or may require special measures to limit or reduce the radiation exposure of persons participating in the emergency work or protective actions or the exposure of members of the public (Radiation Act, Section 4(31)).

Protective actions are measures aimed to minimise the radiation exposure of the public in case of a nuclear or radiological emergency, keep other harm caused by the situation to a minimum and restore the living conditions of people and the functioning of society as normal as possible after the emergency.

Nuclear and radiological emergencies are divided into early, intermediate and recovery phases according to their temporal phase. This guide applies to the early and intermediate phases. In a nuclear or radiological emergency, different areas may be at a different phase of emergency simultaneously if, for example, the release plume moves from one area to another. The guide does not address long-term recovery strategies, but the principles set out can be used in planning the recovery phase.

A serious nuclear or radiological emergency that could require extensive protective actions in Finland may be caused by a very serious nuclear power plant accident in Finland or a nearby area, the use of a dirty bomb or fallout caused by a nuclear explosion. A local nuclear or radiological emergency may be caused by an accident when using or transporting radioactive materials or intentional unlawful use of radioactive materials. This guide is applied to all nuclear and radiological emergencies regardless of their severity or extent.

According to Section 46(2)(9) of the Rescue Act (379/2011), the Radiation and Nuclear Safety Authority shall assess the safety significance of a nuclear or radiological emergency and issue recommendations on protective actions to the authorities deciding on protective actions. The decision on the protective actions shall be taken by the authority competent under the law applicable to the protective measure in question. Acts on the basis of which protective actions are implemented include the Rescue Act (379/2011), the Police Act (872/2011), the Emergency Powers Act (1552/2011), the Health Protection Act (763/1994), the Occupational Safety and Health Act (738/2002), the Food Act (23/2006) and the Waste Act (646/2011).

This guide serves as an essential tool for the preparation of the Radiation and Nuclear Safety Authority's recommendations and a basis for the planning by the authorities and organisations involved in decisions on protective actions. According to the Rescue Act and the Emergency Powers Act, in the event of an accident, key actors are obliged to prepare for accidents, including situations that may lead to a nuclear or radiological emergency, and maintain the necessary preparedness for them. The roles and responsibilities of the various actors and the applicable legislation are discussed in the "Säteilytilanneohje" radiation situation bulletin enacted by the Ministry of the Interior (Ministry of the Interior publications 10/2016). The topic is also covered in the "Säteilyvaara ja suojautuminen" brochure on radiation hazard and protection by the Radiation and Nuclear Safety Agency (STUK).

This guide takes into account the Radiation Act that entered into force on 15 December 2018 and the revised decrees and STUK Regulations issued under it. The guide also takes into account the international principles of radiation protection. The most important principles concerning this guide are included in the International Atomic Energy Agency's (IAEA) requirements GSR Part 7 (Preparedness and Response for a Nuclear or Radiological Emergency) and GSG-2 (Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency) and the International Commission on Radiological Protection's (ICRP) Publication 103 (The 2007 Recommendations of the International Commission on Radiological Protection) and Publication 109 (Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations).

1.2 Concepts and definitions

Absorbed dose represents the radiation energy transferred from the radiation to the tissue. It does not directly represent the undesirable health impacts of radiation (see radiation dose). The unit of absorbed dose is the Gray (Gy).

Dose criterion means a criterion derived for each protective measure on the basis of a reference level above which the protective measure is justified in terms of radiation protection. The dose criterion is determined for an unprotected person.

Becquerel (Bq) is a measure of activity equal to one disintegration of radioactivity per second. For example, the levels of radioactive materials in foodstuffs are expressed in Becquerels per unit mass or volume (Bq/kg or Bq/l).

Site area emergency is a situation during which the nuclear power plant's safety deteriorates or is in danger of deteriorating significantly (STUK Y/2/2018).

Operational intervention level means the external radiation dose rate derived from the protective measure's dose criterion or any other quantity describing the severity of the radiation situation that can be directly measured or estimated, such as the extent of the fallout or activity concentration. When the indicative operational intervention level is exceeded or is anticipated to be exceeded, a protective measure is generally necessary. The operational intervention levels given in this guide are indicative. Depending on the circumstances of the nuclear or radiological emergency, it may be justified to implement protective actions based on other grounds.

Waste containing radioactive material means actual radioactive waste or other waste or an abandoned product. In this document, "other waste and abandoned products" refer to waste, the treatment, management or recovery of which must take into account radiation protection considerations, but in which the amount of radioactive material is so low that they are not considered actual radioactive waste. The definition also includes products which are unfit for the intended use due to slight contamination.

Radioactive fallout refers to the deposition of radioactive material from the air onto different surfaces in- and outdoors. For the purpose of this guide, fallout is also contamination where radioactive materials have been introduced onto different surfaces by inadvertent or intentional spreading. The consequences of fallout are diminished by the decomposition of radioactive material, environmental migration, chemical or biological adhesion to materials and decontamination measures.

Contamination level describes the magnitude of deposition in the affected area. Contamination level is used, for example, in assessing the need for decontamination measures. Contamination level is primarily determined based on the external radiation dose rate from the fallout. However, if the quantities of radioactive materials in the fallout suggest a higher contamination level, that level shall be used. In determining the magnitude of deposition, it is assumed that radioactive materials are still on the soil surface layers and on the surfaces of buildings and objects and have not, for example, penetrated deeper into the soil.

Contamination level	external radiation dose rate after the active plume has passed	Total deposition of strong gamma and beta emitters	Deposition of alpha emitters possibly in non-fixed form on surfaces
Extremely contaminated	over 100 μSv/h	over 10,000,000 Bq/m^2	over 100,000 Bq/m^2
Heavily contaminated	10–100 μSv/h	1,000,000–10,000,000 Bq/m^2	10,000–100,000 Bq/m^2
Contaminated	1–10 μSv/h	100,000 Bq/m^2–1,000,000 Bq/m^2	1,000–10,000 Bq/m^2
Slightly contaminated	less than 1 μSv/h but above the normal background level	less than 100,000 Bq/m^2	less than 1,000 Bq/m^2
Non-contaminated or almost non-contaminated	contamination is so low that the dose rate is at the normal background level	no contamination at all or very low contamination	no contamination at all or very low contamination

Precautionary action zone is an area extending to a distance of approximately five kilometres from a nuclear power plant, where land use restrictions are in force (STUK Y/2/2018).

Protective actions are actions taken to reduce people's exposure to radiation or the possibility thereof in a nuclear or radiological emergency or existing exposure situation. Protective actions may concern people, the living environment, functions of society, industry and commerce, primary production, foodstuffs, water and waste containing radioactive material. The measures aim to reduce long-term harm caused by the radiation situation and ensure the continuity of the living conditions and the functioning of society.

Radiation dose describes the health hazards caused by radiation to an individual. Radiation dose is obtained by multiplying the absorbed dose by a coefficient depending on the type of radiation (see absorbed dose). In this guide, effective dose and equivalent dose are referred to collectively as radiation dose. The unit of radiation dose is the Sievert (Sv). Its sub-multiple units are milliSv, mSv (0.001 Sv) and microSv, μSv (0.000001 Sv).

Radiation level refers to the extent of radioactive fallout on different surfaces (Bq/m^2), the external radiation dose rate (Sv/h) or the activity concentration in air, water or other matter (Bq/m^3).

Radiation situation refers to an overall situation consisting of radiation levels in the environment, taking into account different exposure pathways.

Emergency helper is a person other than an emergency worker who provides assistance in protective actions or participates in other work necessary for society in an emergency exposure situation. Such other work necessary for society includes the maintenance of critical infrastructure such as water and electricity networks, essential medical services and public safety and order. Authorities that do not meet the emergency worker criteria or have not received training as emergency workers are also included in the emergency helper category. For example, tasks related to environmental health control fall within the scope of such measures. [Translation note: The definition of the term differs from “helpers in an emergency” as defined by IAEA Safety Glossary].

Nuclear or radiological emergency refers to an emergency exposure situation in which the consequences of an imminent or actual incident require or may require special measures to limit or reduce the radiation exposure of persons participating in the emergency work or protective actions or the exposure of members of the public.

Reference level for emergency exposure situation (reference level) means the level of radiation dose above which exposures are planned to be prevented for all persons in an emergency exposure situation. The aim is to limit people's exposure to radiation in the first year of the radiation exposure emergency to a maximum of 20 mSv (Radiation Act 859/2018, Section 132). The assessment of the radiation exposure shall consider all exposure pathways caused by the emergency situation and the effects of the protective actions reducing the exposure. The reference level shall be reduced gradually until such time that a permanently acceptable situation is reached.

Emergency worker is a person with a pre-determined task in an emergency exposure situation who may be exposed to ionising radiation in the course of the emergency work or protective actions in an emergency exposure situation. In particular, emergency workers include rescue and emergency medical care personnel and members of the undertaking's emergency organisation. Emergency workers shall be trained in advance on the health effects of radiation and protection against radiation.

External radiation is direct radiation to the human body from outside of the body.

External radiation dose rate indicates the amount of radiation per unit of time a person receives in that location from, for example, an unshielded radiation source or radioactive materials on different surfaces. The dose rate unit is Sieverts per hour (Sv/h). It is usually expressed in microsieverts per hour (μSv/h) or millisieverts per hour (mSv/h).

Hazardous area means an area where there is a need to seek shelter indoors or evacuate and isolate the area. Access to the hazardous area should be restricted to people with essential tasks in the area.

Precautionary Action Zone refers to an area extending to a distance of approximately 20 kilometres from a nuclear power plant and for which authorities shall draft an external emergency plan referred to in Section 48 of the Rescue Act (379/2011) (STUK Y/2/2018).

Precautionary area means an area where the protective actions needed are less strict than seeking shelter indoors or evacuation.

Strong gamma and beta emitters are nuclides that emit gamma or beta radiation in excess of 500 keV of energy. Examples of these include the following nuclides: cobalt-60 (^{60}Co), ruthenium-106 (^{106}Ru), silver-110m (^{110m}Ag), iodine-131 (^{131}I), caesium-134 (^{134}Cs), caesium-137 (^{137}Cs), cerium-144 (^{144}Ce), strontium-90 (^{90}Sr), iridium-192 (^{192}Ir) and radium-226 (^{226}Ra). Other gamma and beta emitters are **weak gamma and beta emitters**. Examples of these include tritium (^{3}H), chromium-51 (^{51}Cr), iron-55 (^{55}Fe) and nickel-63 (^{63}Ni).

General emergency is a situation during which the hazard of such a radioactive material leak exists that may require protective actions in the vicinity of a nuclear power plant (STUK Y/2/2018).

1.3 Phases of a nuclear or radiological emergency

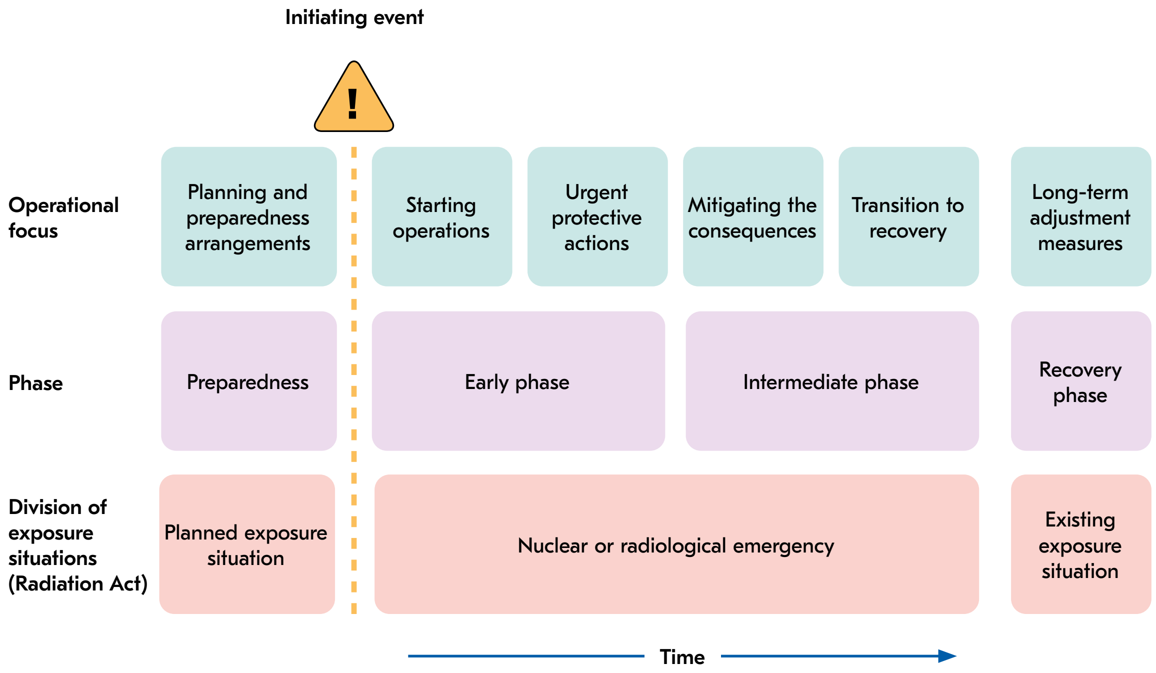


FIGURE 1. Development and phases of a nuclear or radiological emergency. [Translation note: This translation uses ICRP terminology for phases of emergency as it is closer to literal translation of the Finnish terms. Thus, Early Phase in this document corresponds to Urgent Phase in IAEA terminology and Intermediate Phase in this document corresponds to Early Phase in IAEA terminology.]

The early phase of a nuclear or radiological emergency includes both the initial events before the release of radioactive materials into the environment or the deterioration of their shielding and the dispersion of radioactive materials in the environment. The early phase ends when the radiation level in the environment no longer increases significantly, and there is no further threat of additional release of radioactive materials in the environment or when the radiation source has been brought into a safe state.

Key protective actions in the early phase include sheltering indoors, iodine prophylaxis, access restrictions, evacuation of the immediate vicinity of the incident site and protection of workers participating in handling the situation. These measures aim to limit people's immediate exposure to radiation. In addition, primary food and animal feed production, other production and various facilities must be protected to reduce their contamination. At the beginning of the early phase, estimates concerning the severity and development of the radiation situation are often very uncertain. Various dispersal model calculations can be used to assess potential threat areas at this phase. However, the determination of the actual hazardous area also requires information on the quantities of radioactive materials released and the pathway and time of the release. Uncertainties may lead to a need to make rapid decisions on protective actions without comprehensive information on the situation.

In the intermediate phase of a nuclear or radiological emergency, radiation levels in the living environment no longer rise significantly, and further releases of radioactive materials into the environment are not expected. The possibility of lifting, relaxing or modifying the protective actions implemented in the early phase shall be assessed in this phase. In addition, new protective actions are launched as necessary to reduce radiation exposure and the quantity of radioactive material in the living environment. The measures aim to ensure the radiation safety of people and the continuation of the functions of society, industry and commerce. The intermediate phase can last up to a few years. The duration depends on the extent and severity of the radiation hazard, for example.

Also, there may be no preceding early phase, or the early phase may be very short. This may be the case if the environment, foodstuffs or other material is contaminated intentionally. In this case, protective actions are triggered directly in the intermediate phase.

If the nuclear or radiological emergency results in long-term effects on the living environment, the intermediate phase will be followed by a recovery phase. In this case, the radiation situation in the living environment is permanently acceptable from the viewpoint of the society, and the activities of people and the society are adjusted to the prevailing radiation situation. Recovery typically includes actions by the members of the public to reduce their own exposure, based on expert recommendations and advice and the local and social conditions. The decontamination of the environment from radioactive materials can continue along with the management of waste containing radioactive material. Long-term restrictions regarding the use of areas with unsatisfactory radiation situations are imposed, or the use of these areas and production are redirected. The recovery phase may last up to decades. The recovery phase is not part of a nuclear or radiological emergency. The measures to be taken during it are not included in this guide. However, some principles in this guide, such as the decontamination of the living environment and management of waste, can also be applied during the recovery phase.

1.4 Grounds for protective actions

The objective of protective actions in a nuclear or radiological emergency is to keep human radiation doses as low as reasonably achievable without causing more harm than good. The protective actions also aim to keep other harm caused by the situation to a minimum and restore people’s living conditions and the functioning of the society as much as possible.

Nuclear or radiological emergencies can cause radiation exposure in many ways. Possible exposure pathways include

- external radiation from an unshielded radiation source, fallout or airborne radioactive material
- radioactive material in inhaled air
- contaminated foodstuffs and household water
- contamination of the skin
- the introduction of radioactive material into the body by other routes, for example, through transfer to the mouth from contaminated hands, through an open wound or through absorption through the skin.

The geographical scope of a nuclear or radiological emergency may vary considerably. Annex 1 contains examples of the areas affected by different nuclear or radiological emergencies.

1.4.1 Health hazards caused by radiation

Health hazards caused by radiation can be divided into direct health hazards and random effects. Reduction of the population's radiation exposure aims to prevent the direct health hazards caused by radiation (radiation injuries, radiation sicknesses, deaths) and minimise the random effects of radiation (cancer) as much as possible.

Direct health hazards caused by radiation are due to the destruction of cells. The likelihood of tissue damage starts to increase when a person receives a dose of more than 100 mSv in a short period of time, for example, a day. At doses of 1,000 mSv or greater, the amount of tissue damage is so severe that adverse health effects (transient nausea and transient changes in blood count) start to occur. A dose in excess of 3,000 mSv causes a serious radiation sickness requiring hospital treatment. If the dose received in a short period of time exceeds 6,000 mSv, the likelihood of death is high.

Direct health hazards can occur
- in the immediate vicinity of a strong unshielded radiation source
- to an unprotected person in the vicinity of a nuclear power plant in case of an extremely high release of radioactive materials into the environment
- to an unprotected person up to a few hundred kilometres from a place where a nuclear weapon was detonated; the extent of the hazardous area greatly depends on how powerful the nuclear weapon was, the detonation height and the weather conditions
- after ingesting heavily-contaminated food or drink that has been deliberately contaminated with radioactive material.

Random effects of radiation are due to changes in the cell's genome which can cause cancer. Random effects may occur regardless of the radiation dose magnitude. The effects typically only appear after a long time. The probability of random effects for an individual in an accident situation is low: a dose of 100 mSv increases the risk of getting cancer on average by about 0.5%. Studies on exposed people have also suggested that doses above 500 mSv may increase the risk of cardiovascular disease[1].

1.4.2 Reference level of exposure for a nuclear or radiological emergency

The reference level of exposure for a nuclear or radiological emergency refers to the target level below which the radiation doses received should remain. The reference level is used to determine the criteria for the necessity of protective actions throughout the emergency

1 ICRP Publication 103: The 2007 Recommendations of the International Commission on Radiological Protection (Annex A.5)

exposure situation. The reference levels are set with consideration to the principles of radiation protection and acceptability in terms of society. The reference level of exposure for a nuclear or radiological emergency is 20 mSv in the first year (Radiation Act, Section 132). To reduce people's exposure to radiation, easily and reasonably implementable protective actions are carried out even at doses below the reference level.

The effectiveness and success of the protective actions are assessed by comparing the received doses to the reference level. The radiation exposure assessment includes all exposure pathways during the emergency situation, such as inhaled air, external exposure, foodstuffs and household water and skin contamination. The assessment also considers the effects of the protective actions decreasing the exposure. A more detailed description of the measurements carried out as the basis for the dose assessment can be found in the Radiation and Nuclear Safety Authority's plan for measurement activities.

The reference level should be assessed throughout the emergency and adjusted as necessary. This means that the criteria for the necessity of the protective actions change accordingly. The reference level is reduced over time until a permanently acceptable level of radiation doses received is achieved with the protective actions (Figure 2).

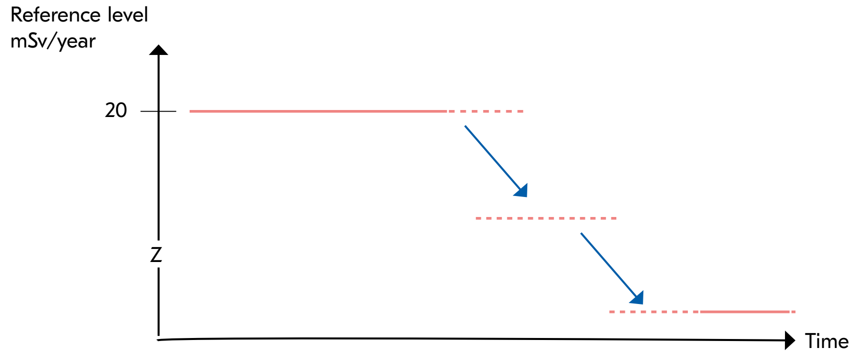


FIGURE 2. The aim is to reduce the reference level of the dose due to the emergency exposure situation as quickly as possible to achieve a permanently acceptable situation.

1.4.3 Dose criteria and indicative operational intervention levels for protective actions

A dose criterion based on the reference level has been established for each protective measure. The criteria are presented in this guide. When the dose criterion is expected to be exceeded or has been exceeded, a protective measure is generally necessary to keep the dose received by individuals during the situation below the reference level.

Radiation dose received by members of public is a calculated value. Indicative operational intervention levels are derived from the dose criteria and can be directly verified by means of measurements. Indicative operational intervention levels are given as an external radiation dose rate, activity concentration or magnitude of deposition. Examples of indicative operational intervention level calculations are provided in Annex 3.

The dose criteria and intervention levels set out in the guide are not strict absolute limit values but approximate magnitudes and indicative levels. The magnitudes are sufficiently precise for assessing the exposure in an emergency exposure situation, as the situation, its development, and the forecasts used are subject to significant uncertainties.

The dose criteria and indicative operational intervention levels provided in the guide for protective actions are defined for population groups that may be exposed. Protective actions targeting certain population groups, such as children, can also be implemented if the situation so requires. Particular attention is paid to those most exposed, with additional instructions given to reduce their radiation exposure.

The combined dose caused by different exposure pathways in a nuclear or radiological emergency may exceed 20 mSv per year even if the protective actions are carried out in accordance with the intervention levels in this guide. Exceedance is possible, for example, if the measures are not implemented timely or are less effective than expected.

It is possible that some people will receive in an accident an annual dose of more than 100 mSv, i.e. a significantly higher dose than the reference level for radiation exposure. Persons who have received such a dose shall be registered and provided with long-term health surveillance. The registered dose shall include only the exposure caused by the nuclear or radiological emergency.

1.5 Factors affecting the choice of protective actions

The need for protective actions shall be assessed at the latest when there is a possibility that any of the dose criteria or indicative operational intervention levels laid down in this guide will be exceeded. The consideration, choice and implementation of protective actions shall take into account the following:

- the incident and its expected development
- the uncertainties related to the incident
- the duration of the exceedance of dose criteria
- the necessary duration of the protective actions
- the harm caused by the protective actions
- other circumstances, such as the time and resources available to carry out the measures.

The choice of protective actions is also affected by their assumed duration. For example, a rapid, short-term evacuation together with environmental clean-up measures is probably preferable to a temporary relocation of the population lasting several months. Decisions on long-term protective actions lasting several months or years are also significantly influenced by other than radiation protection-related criteria, such as any social, psychological and economic harm.

In the early phase, the assessment of the need for and the choice of protective actions are largely based on predictions of the temporal and local development of the nuclear or radiological emergency. The implementation of the protective actions takes hours, so predictions are needed to carry the measures out in a timely manner. The consideration of protective actions in the vicinity of a domestic nuclear power plant is primarily based on a forecast of the development of the situation at the plant.

Particularly in the intermediate phase, a wide range of protective actions and their combinations are available for consideration. The combined effect of different protective actions on the magnitude of the remaining exposure level shall be considered in reducing the exposure and assessing the situation. Although the intervention levels given in this guide are based on radiation effects, the final choice of protective actions depends on a number of factors, including the ones presented in Figure 3. One important factor in reducing the radiation dose is the actions taken by people themselves. The authorities provide instructions for these actions based on the prevailing radiation situation and other conditions. Annex 6 includes ways for people to reduce their exposure themselves. Effective official communications help both to reduce exposure by directing people's own actions and support social recovery.

The measures to be implemented are chosen or left out considering their respective advantages and disadvantages. In addition to exposure, adverse effects may include, for example, ethical, social, environmental or economic impacts. In serious radiation conditions, where doses would be high without protective actions, it is essential to limit radiation exposure. In this case, measures must be implemented even if they would cause serious inconvenience to people's normal lives or high costs. In moderate radiation conditions, where exposure remains low, other impacts outweigh the radiation exposure when deciding on the measures.

The predictions of doses and the doses received by people both include major uncertainties. Protective actions are likely justified if the projected annual radiation dose due to the nuclear or radiological emergency without any protective actions is as follows:

- higher than 10 mSv; appropriate protective actions to reduce the exposure of the general public are necessary
- between 1 and 10 mSv; some protective actions are usually appropriate
- below 1 mSv; protective actions to reduce exposure may be applied where they are readily and appropriately achievable.

Protective actions are absolutely necessary and must be applied as a matter of urgency if there is a risk of doses exceeding 100 mSv in a short period of time (approximately one day). This corresponds to an external dose rate of approximately 4,000 μSv/h for 24 hours.

The management of a nuclear or radiological emergency may continue for years. Efforts should be made to reduce the dose to the population throughout the emergency until the exposure conditions are acceptable to society.

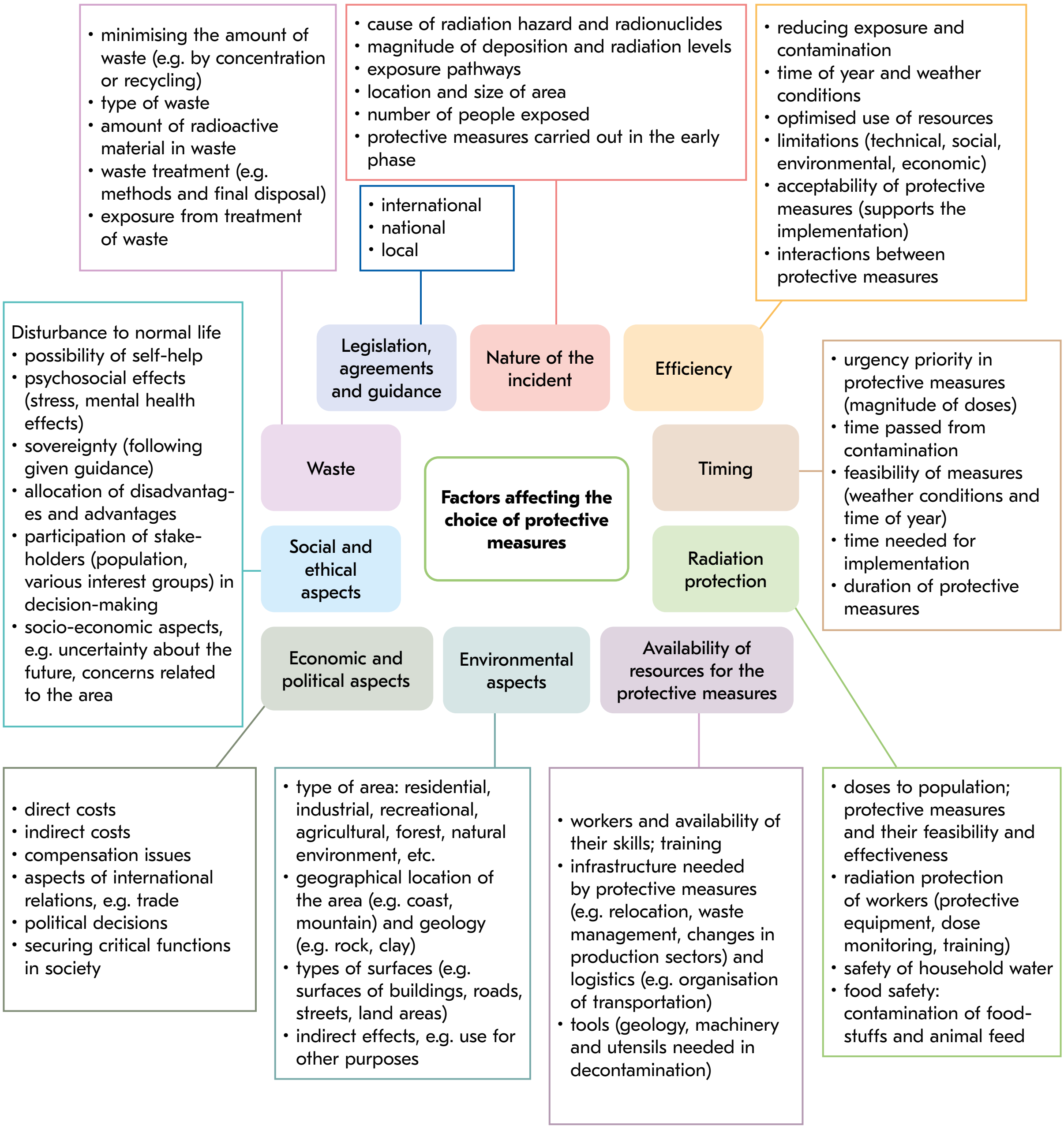


FIGURE 3. Factors affecting the choice of protective actions in the intermediate phase.

1.6 Protective actions considered in a nuclear or radiological emergency

There may be several possible exposure pathway possibilities simultaneously in a nuclear or radiological emergency. In this case, several complementary protective actions are also needed to cover all exposure pathways. The protective actions set out in the guide form a whole where the implementation of an individual measure may have a direct or indirect impact on a wide range of functions in society and the decisions of the different actors on the measures. Examples of this include the impact of access restrictions on logistics and production and the impact of evacuation on social services at the places receiving the people. The chosen measures may have an impact on other necessary protective actions. For example, in an area where the population is sheltering indoors, it is not possible to protect primary food production because it would require going outdoors.

The need to implement new protective actions and to modify, continue or terminate those already implemented shall be evaluated throughout the situation. The evaluation is based on the chosen reference level. The assessment shall consider the effectiveness of the protective actions already applied in terms of exposure reduction and, on the other hand, their impact on human activities and functions of society, and also the rate at which the amount of radioactive material in the environment is reduced due to radioactive degradation or decontamination measures. It may be necessary to follow more stringent criteria in the intermediate phase than those described for the individual protective actions if, for example, the exposure in the early phase has already resulted in a dose close to the reference level.

The protective actions, dose criteria and indicative operational intervention levels provided in this guide apply to different types of emergency exposure situations. Although a separate set of criteria is provided for the need for each protective measure, different mutually complementary measures are implemented simultaneously during an emergency. Examples of simultaneous protective actions in the early phase include sheltering indoors, iodine prophylaxis and access restrictions. Annex 2 presents the indicative operational intervention levels for all protective actions provided in the guide.

Protective actions in the early phase of a nuclear or radiological emergency target particularly people and production. In this phase, the objective is to protect people and facilitate and mitigate the actions needed in the intermediate phase. Besides people and production, protective actions in the intermediate phase of a nuclear or radiological emergency target the living environment and the restoration of societal functions. The early- and intermediate-phase protective actions included in this guide are presented in Figure 4 and Figure 5, respectively. Many measures result in radioactive waste, the proper management of which requires special care.

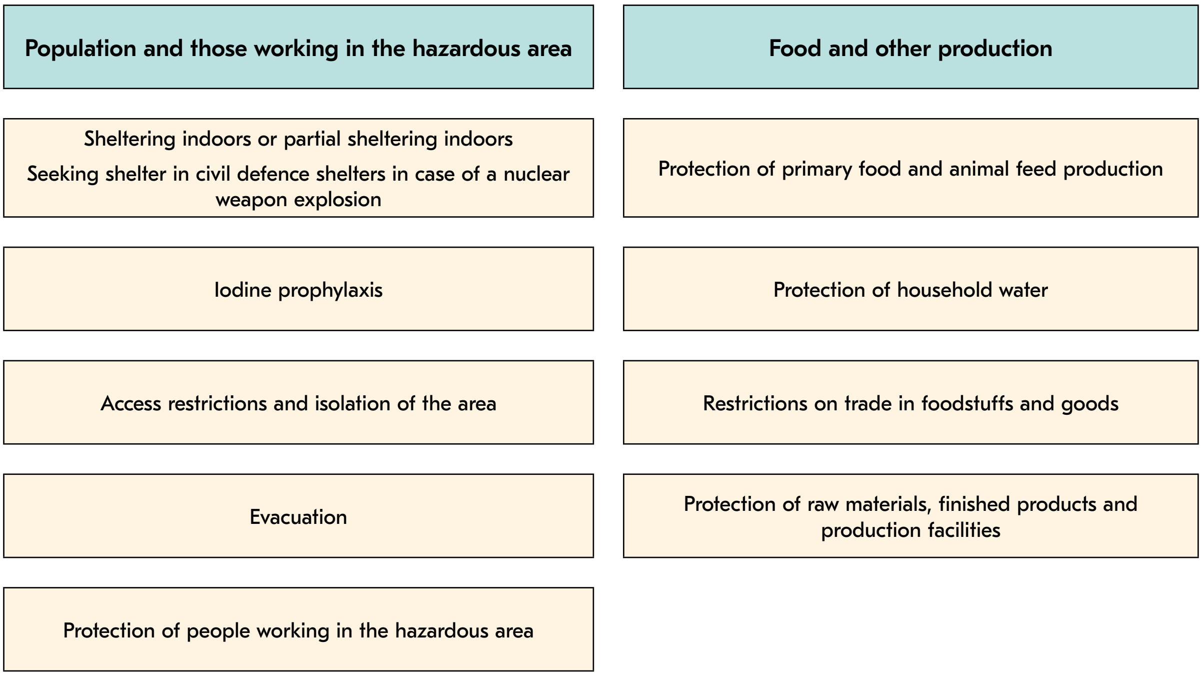


FIGURE 4. Protective actions in the early phase of a nuclear or radiological emergency.

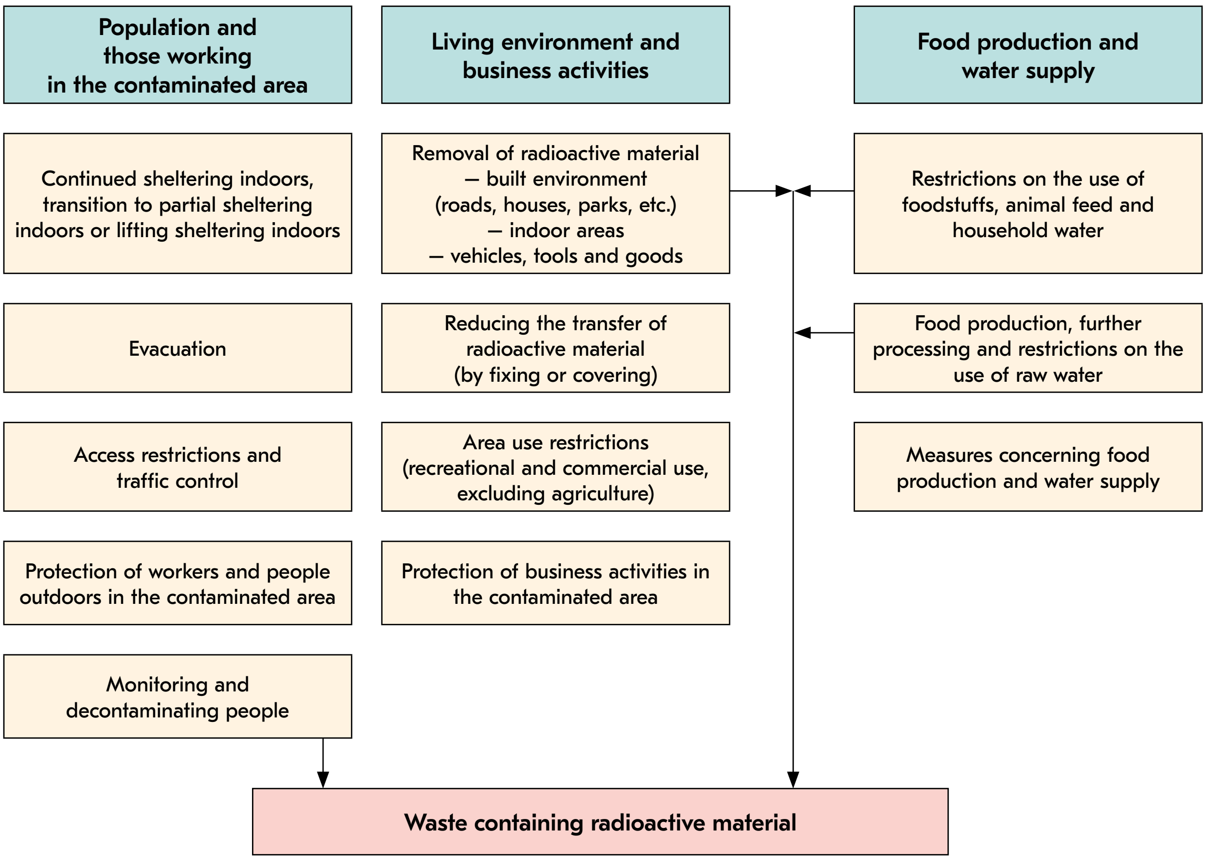


FIGURE 5. Protective actions in the intermediate phase of a nuclear or radiological emergency.

1.7 Responsibilities in the implementation of protective actions

The protective actions required in a nuclear or radiological emergency and their extent depend significantly on the resulting incident, the type and quantity of the radioactive material that may be released into the environment and the extent of the affected area. A particularly serious emergency exposure situation requires wide-ranging measures decided by many authorities, actions by the people to reduce their exposure themselves and actions by the private sector to ensure the continuity of their activities. The management of local emergency exposure situations, on the other hand, is likely to require action by only a few authorities.

Due to the number of responsible actors and applicable provisions, this guide does not include a detailed breakdown of responsibilities. The authorities' responsibilities and regulatory basis are described in detail in the "Säteilytilanneohje" radiation situation bulletin by the Ministry of the Interior (Ministry of the Interior publications 10/2016). Annex 4 contains a summary table of the main actors' responsibilities in the radiation situation bulletin.

The actors' radiation measurement responsibilities are determined by the national measurement strategy group (SMDno-2015-706) appointed by the Ministry of the Interior. The mandate of the working group includes a wide-ranging survey of actors performing radiation measurements and the measuring capacity, including the respective cooperation and flow of information. Coordination of international assistance with national measurement activities shall also be determined. The strategy produced by the working group is to be published in 2020.

2. Protective actions in the early stages of a nuclear or radiological emergency

2.1 Measures to protect members of the public

2.1.1 Sheltering indoors in the early phase

Sheltering indoors refers to taking shelter in ordinary indoor facilities, shutting off the ventilation and, where possible, sealing the air vents. Sheltering indoors reduces the passage of airborne radioactive material into the body and the radiation dose from external radiation. The duration of sheltering indoors should not exceed two days. Otherwise, non-radiation-related issues, such as problems with access to food and medicines, will increase rapidly. Also, with the release plume in the area, indoor facilities become contaminated in about two days regardless of sealing and shutting off the ventilation, thus reducing the effectiveness of sheltering indoors. Annex 5 describes the reduction of exposure when sheltering indoors.

Seeking shelter in normal indoor facilities is usually a sufficient measure in case of an emergency exposure situation. However, an exception to this is a serious radiation hazard due to a nuclear explosion that requires seeking shelter in civil defence shelters.

DOSE CRITERION FOR SHELTERING INDOORS:

– The projected radiation dose to an unprotected person in two days exceeds 10 mSv.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR SHELTERING INDOORS:

– the external dose rate exceeds or is anticipated to exceed 100 μSv/h

or

– the concentration of radioactive material in the air exceeds or is anticipated to exceed one of the following:

- alpha emitters 1 Bq/m^3 (plutonium-239 and americium-241)
- beta emitters 1,000 Bq/m^3 (strontium-90)
- caesium-137, iodine-131 and other strong gamma emitters in total 10,000 Bq/m^3

The aim is to have the sheltering indoors implemented before the arrival of radioactive material in the area. To ensure timely sheltering indoors, the decision on the measure should be made no later than four hours before the need to seek shelter arises. This way, members of the public can be given the necessary instructions and sheltering indoors implemented in good time. In case sheltering indoors before the arrival of radioactive material in the area fails, it should take place as soon as possible.

In the hazardous area, ventilation in all buildings, including residential buildings, public buildings, premises and production facilities, must be shut off where ever possible. Doors, windows, air vents and other openings providing ventilation, such as flues, must be sealed as tightly as possible by, for example, taping any gaps and door and window frames. Shutting off the ventilation system reduces people's exposure to radiation by significantly reducing the passage of radioactive materials indoors. Household textiles and other indoor items prone to collecting dust should be protected by, for example, covering or packing them in plastic bags, if feasible, to facilitate the subsequent decontamination of the indoor facilities.

To reduce indoor contamination, ventilation should also be shut off in buildings that are not used for sheltering indoors if this can be done before the arrival of radioactive material in the area. If there is not enough time to protect all buildings, priority shall be given to buildings needed to restore the normal functioning of society after the emergency, such as schools and grocery shops.

There is still a need to maintain critical infrastructure, essential medical services and public safety and order in areas designated as areas for sheltering indoors. The radiation protection of people carrying out these tasks is discussed in chapter 2.3.

In areas requiring sheltering indoors, protective actions requiring residents to go outdoors after the start of the sheltering indoors should not be imposed, such as measures to protect primary production.

Seeking shelter in civil defence shelters

A radiation situation resulting from a detonation of a nuclear weapon is different from, for example, a radiation situation resulting from a serious nuclear power plant accident. A nuclear explosion produces a large amount of highly radioactive materials and can quickly result in an extremely high dose rate. In this case, seeking shelter in civil defence shelters is necessary. If no civil defence shelter is available or can be taken into use quickly, protection should be sought by staying indoors. The safest place is in the middle parts of the building or in the basement in a room without large windows. This helps to reduce exposure to external radiation.

DOSE CRITERION FOR SEEKING SHELTER IN CIVIL DEFENCE SHELTERS:

– The projected radiation dose to an unprotected person in one day exceeds 100 mSv.

Detonation of a nuclear weapon may require very rapid protective actions, possibly making it very difficult to obtain accurate information on the situation at an early stage. Therefore, the first protective actions would probably be based on the rapid prediction models developed for a nuclear detonation situation.

2.1.2 Partial sheltering indoors in the early phase

It is possible to spend time outdoors during the restriction, but it must be limited to the minimum necessary. The measure is required when there are radioactive materials in the outside air and the environment, but not to the extent of making strict sheltering indoors necessary. It is especially important for children and pregnant and breastfeeding women to avoid time outdoors as much as possible since children and foetuses are more sensitive to radiation.

Ventilation of buildings in areas requiring partial sheltering indoors should be shut off. It will reduce human exposure and indoor contamination. However, it is not necessary to separately seal ventilation openings and penetrations.

DOSE CRITERION FOR PARTIAL SHELTERING INDOORS:

– The projected radiation dose to an unprotected person in two days is 1–10 mSv.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR PARTIAL SHELTERING INDOORS:

– the external dose rate exceeds or is anticipated to exceed 10 μSv/h

or

– the concentration of radioactive material in the air exceeds or is anticipated to exceed one of the following:

- alpha emitters 0.1 Bq/m^3 (plutonium-239 and americium-241)
- beta emitters 100 Bq/m^3 (strontium-90)
- caesium-137, iodine-131 and other strong gamma emitters in total 1,000 Bq/m^3.

2.1.3 Iodine prophylaxis

Exposure to radioactive iodine can occur by inhalation, especially if it is present in the inhaled air due to, for example, a nuclear power plant accident. Radioactive iodine can also enter the body through contaminated foodstuffs, drinking water or contaminated surfaces from the hands to the mouth. If radioactive iodine gets in contact with the skin, it will penetrate the skin. Inside the body, radioactive iodine accumulates in the thyroid gland, subjecting it to a radiation dose.

Timely taking of iodine tablets can effectively reduce the accumulation of radioactive iodine into the thyroid gland. With age, the benefit of iodine tablets decreases and the likelihood of side effects increases. Therefore, iodine tablets should be taken by the population up to the age of 40. In addition, pregnant women should take iodine tablets at any age to protect the thyroid gland of the foetus. If there are not enough tablets to everyone up to the age of 40, children and pregnant women should be given priority because the thyroid gland of children and foetuses is more sensitive to radiation than those of adults. The iodine tablet only protects the thyroid gland; it does not reduce other exposure.

Taking iodine tablets is a supplementary protective measure for sheltering indoors. Sheltering indoors significantly reduces the amount of radioactive material entering the body by inhalation (see Annex 3), thus reducing the dose to the thyroid gland by iodine. People should not go out to buy iodine tablets when there is a recommendation to shelter indoors in force.

DOSE CRITERION FOR IODINE PROPHYLAXIS:
– the dose to the thyroid gland is estimated to be
– over 100 mGy for 18–40-year-olds, or
– over 10 mGy for children under 18 and pregnant women.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR IODINE PROPHYLAXIS:

18–40-year-olds:
– the external dose rate exceeds or is anticipated to exceed 100 μSv/h
or
– iodine in inhaled air is or is anticipated to exceed 10,000 Bq/m^3

Children under 18 years of age and pregnant women:
– the external dose rate exceeds or is anticipated to exceed 10 μSv/h
or
– iodine in inhaled air is or is anticipated to exceed 1,000 Bq/m^3

The dosage is according to the instructions on the iodine tablet package. Separate dosing instructions are provided for children under three years of age. Persons hypersensitive to iodine or diagnosed with, for example, perturbation or some other condition of the thyroid gland should not take iodine tablets.

One dosage of iodine gives protection for one day and partially for another successive day. The iodine should be taken 1–6 hours before exposure to radioactive iodine, which gives 100% protection. The later the iodine is taken, the weaker the protection. The iodine dose is of no use if it is taken more than 12 hours after inhalation of radioactive material. To ensure correct timing, the iodine tablet should only be taken as directed by the authorities.

If the radioactive plume remains over the locality for more than 24 hours, another dose of iodine should be considered based on the concentration of iodine in the air. The operational intervention levels for the second dose are the same as given above. That said, a second iodine dosage should not be given to newborn babies under one week old to avoid disturbing the function of the thyroid gland.

Food control and guidelines for primary production shall ensure that foodstuffs containing harmful levels of radioactive iodine are not used. Similarly, household water monitoring and guidelines on household water use shall ensure that household water containing harmful levels of radioactive iodine is not used.

2.1.4 Evacuation in the early phase (protective evacuation)

Evacuation of the public means the moving of the population or part of the population under the direction of the authorities or independently in accordance with appropriate instructions to a safe area. The concept of evacuation does not include people moving away on their own initiative. However, people's moving away on their own initiative from an area deemed to be dangerous must be considered in emergency response plans, including directing traffic to an area where there is no need for protective actions.

Evacuation is a general concept which includes a range of actions of varying duration. For the purpose of this guide, evacuation is divided into *protective evacuation*, which is an urgent evacuation by order of the rescue authority (Rescue Act, Section 2a), temporary relocation of the population (chapter 3.1.7) and permanent relocation (chapter 3.1.7). The principles set out in this guide apply to all types of evacuations in case of a nuclear or radiological emergency. Any evacuation in the early phase of a nuclear or radiological emergency is a protective evacuation by nature.

Evacuation is usually not the primary mode of action in an acute emergency exposure situation. Instead, the aim is to protect members of the public by sheltering indoors. However, in the event of a serious domestic nuclear power plant accident, protective evacuation may be carried out in the vicinity of the plant (chapter 2.1.5).

In case of an accident involving a threat of radioactive material spreading from radiation sources to in- or outdoor areas, people in the isolation area (see chapter 2.2.2, Table I) must be evacuated immediately. Evacuation is also necessary in case of other radiation hazards caused by radiation sources, such as direct radiation.

Evacuation is carried out in a systematic manner to protect people from contamination as much as possible. Evacuees must be instructed on the items they should take with them. They must also be instructed on the condition in which the dwelling should be left. Evacuated people must be moved far enough to an area where protective actions are not required.

If there are sites (e.g. hospitals or medical facilities) in the evacuation area where the rapid removal of people is risky, separate consideration must be given to the implementation and timing of the evacuation. Even if the area is to be evacuated, sheltering indoors may be a justifiable option for sites where there is a high risk associated with the transfer of people.

It is necessary to maintain the critical infrastructure in the evacuated areas. The radiation protection of people carrying out these tasks is discussed in chapter 2.3.

Evacuations in the intermediate phase are discussed in section 3.1.7.

2.1.5 Immediate measures at an emergency planning zone of a domestic nuclear power plant

In case of a threat of an accident in a domestic nuclear power plant that could lead to a release of large amounts of radioactive material, the authorities have to make rapid decisions to protect the public in the plant's emergency planning zone. The need for protective actions depends on the prevailing situation at the plant, the estimate of its development and the likelihood of release of radioactive material into the environment. The type, magnitude and timing of the possible release cannot be estimated for certain. Therefore, the indicative operational intervention levels can be applied in the emergency planning zone only after the release into the environment has started.

The basis for preparedness and preparedness planning is to have protective actions in the emergency planning zones implemented about four hours after the rescue services command has decided to launch protective actions. To ensure that protective actions can be launched in a timely manner, the authorities must begin arrangements for possible evacuation and/or sheltering indoors (e.g. preparation of necessary instructions, resources to enforce access restrictions, distribution of iodine tablets) already when the nuclear power plant's emergency response organisation announces a site area emergency at the plant.

If there is a threat of a significant release of radioactive material into the environment at the nuclear power plant, the precautionary action zone must be evacuated (protective evacuation) and persons up to age of 40 and pregnant women over the age of 40 in the zone must be instructed to take an iodine tablet. An announcement of a general emergency by the nuclear power plant's emergency organisation always implies a risk of release requiring such protective actions. However, a decision on protective actions may be taken regardless of the emergency situation classification if other information indicates that there is a serious threat of release. Such a threat of release may result, for example, from a situation where the reactor may be damaged rapidly or there is a risk of a deliberate attempt to damage the reactor. If the evacuation cannot be carried out before the start of the release due to, for example, the rapid development of the situation or severe weather conditions, people in the precautionary action zone must seek shelter indoors and those up to the age of 40 and pregnant women over the age of 40 should take an iodine tablet.

Evacuees must move far enough to an area where protective actions are not required. In the case of a serious nuclear accident, for example, they may even have to move further than 100 kilometres away. The evacuation ordering authority must issue instructions to evacuees regarding the items to take with them, such as hygiene products, medicines, change of clothes and identity and bank cards. The instruction must also include shutting off indoor ventilation when leaving the dwelling.

In the case of a general emergency, sheltering indoors must be initiated elsewhere in the emergency planning zone where the potential release is expected to reach. Sheltering indoors in the emergency planning zone should be initiated early enough to have it completed before the start of the release. If this is not possible or if the start time of the release cannot be predicted, sheltering indoors must be implemented as soon as possible. In addition to sheltering indoors, iodine tablets must also be taken by persons up to the age of 40 and pregnant women over the age of 40. People without a place to shelter indoors, such as those in the outdoor recreation areas, must be evacuated from the release plume's path before the start of the release.

If the release will continue or is anticipated to continue for more than two days, it may be necessary to reduce the radiation exposure by partly or entirely evacuating the public sheltered indoors even if there is still radioactive material in the air. The right timing for implementing the measure requires an estimate of the development of the accident situation and the level of further release of radioactive material into the environment. Weather conditions must also be considered.

2.2 Limiting public access to the area

2.2.1 Access restrictions in the early phase

Access restrictions refer to measures that restrict access to the hazardous area other than for essential tasks. Restrictions are used to prevent unnecessary human exposure and vehicle contamination. Access restrictions are needed in situations where radioactive materials spread or may spread over a large area.

ACCESS RESTRICTION CRITERIA:

– Areas under sheltering indoors or evacuation orders shall be imposed with simultaneous access restrictions.

Access restrictions may concern road, rail, water and air traffic as well as harbours and airports. The restricted area must be clearly marked on traffic routes or implemented by traffic control measures. The restrictions shall be further specified as more detailed information on the radiation situation becomes available. The operation of ships, trains and aircraft in areas where they may be contaminated should be avoided as they are much more difficult to decontaminate than other vehicles.

If radioactive material released in an accident creates a release plume, air traffic may need to be restricted in areas and at altitudes where aircraft may be contaminated with radioactive material.

2.2.2 Isolation of an area

Incident site surroundings must be isolated if there is a risk of radioactive material spreading in- or outdoors from radiation sources or due to intentional spreading of radioactive material or another radiation hazard due to radiation sources, including the risk of exposure to direct radiation. Isolation may be used as a protective measure in situations where radioactive material remains confined within a limited area. People in the isolated area are evacuated and monitored for possible contamination and need for decontamination. The contaminated area is cleaned. Table I provides indicative instructions on the size of the area to be isolated in response to various events with radiation sources.

TABLE I. Size of the isolation area in different situations.

Site of incident outdoors	Size of the isolation area
• unexploded or exploded "dirty bomb"[2] • fire or explosion (e.g. gas explosion) at a site where there may be a high-activity radiation source or several sources with total activity exceeding the limit of a high-activity radiation source	• area in which the dose rate exceeds 100 μSv/h with, however, a radius of at least 300 m
• possible high-activity radiation source that is damaged, leaking or without a protective shield; no risk of explosion or fire	• area in which the dose rate exceeds 100 μSv/h with, however, a radius of at least 30 m
• other than a high-activity radiation source that is damaged, leaking, without a protective shield or exposed to fire	• area in which the dose rate exceeds 100 μSv/h with, however, a radius of at least 6 m

Site of incident indoors	Size of the isolation area
• possible high-activity radiation source that is damaged, leaking or without a protective shield and located indoors	• area in which the external dose rate exceeds 100 μSv/h, including, however, at least the adjacent rooms and the floors above and below • in case of leakage of a gaseous radiation source: area in which the external dose rate exceeds 100 μSv/h, including, however, at least any room where radioactive materials can find their way, possibly the whole building
• other than a high-activity radiation source that is damaged, leaking or without a protective shield	• the room containing the radiation source including, however, also adjacent rooms where the external dose rate exceeds 100 μSv/h
• possible melting of a high-activity radiation source in metal smelting	• areas in which the external dose rate exceeds 100 μSv/h, including, however, at least the smelting plant and facilities and areas used for handling or storing contaminated material

Note! The external dose rate does not account for all exposure pathways. Therefore, it must not be used as justification for downsizing the isolation area. Downsizing can be done only after the radioactive material in question has been determined in more detail, and the estimates on the spreading, the anticipated amounts of radioactive material in the inhaled air, and the actual contamination level in the area are known.

2 Dispersal of radioactive material into the environment by conventional explosive.

2.3 Radiation protection of workers in the early phase

2.3.1 Radiation doses received from urgent and essential tasks

Persons involved in performing emergency protective actions, bringing the situation under control and other essential tasks are emergency workers or emergency helpers. Emergency workers are persons tasked to perform the above-mentioned duties and who have received regular training in the performance of the duties in advance. In particular, emergency workers include rescue department personnel and the personnel of emergency organisations of undertakings pursuant to the Radiation Act. Other persons participating in the tasks in question are emergency helpers.

Protective actions must be implemented in a way avoiding unnecessary radiation exposure to emergency workers and helpers. However, emergency workers and helpers participating in the tasks may still be more exposed to radiation than members of the public. Radiation protection shall primarily follow the dose limits for radiation workers. The aim shall be that the annual doses to the emergency workers and helpers do not exceed 20 mSv. (Radiation Act, Section 134(2)). Implementation of duties that may result in exposure to radiation may not be assigned to pregnant or breastfeeding women or individuals younger than 18 years of age (Radiation Act, Section 134(1)).

The 20 mSv dose limit may be exceeded if it is necessary in order to implement urgent and essential measures. Emergency workers must be used for such tasks unless it is absolutely necessary to use an emergency helper. If the 20 mSv dose must be exceeded, doses to the emergency workers and helpers should be kept below 100 mSv except for situations related to the prevention of severe health effects due to radiation, life-saving measures or the prevention of the aggravation of an accident. In the case of such measures, the doses should be kept below 500 mSv (Radiation Act, Section 132; Government Decree 1034/2018, Section 46).

According to the Radiation Act, emergency helpers' participation in protective actions must be voluntary. The participation of emergency workers in protective actions must also be voluntary if it is possible that the 100 mSv dose will be exceeded. (Radiation Act, Section 132(1)). Emergency workers and helpers must be aware of the risks related to the task, and the employer or party having the work done must provide guidance on safe work before performing the task (Radiation Act, Section 136).

Doses to the emergency workers and helpers must be determined (chapter 2.3.3), and the results reported to the Radiation and Nuclear Safety Authority. Also, the workers must be informed immediately if the dose exceeds 20 mSv. An opportunity for a health examination must be arranged for emergency workers and helpers who have been exposed in the course of their work or who request to have a health examination. Longer-term health monitoring is required when justified by the exposure received in the course of performing the task (Radiation Act, Section 135).

2.3.2 Actions for mitigating the consequences of the accident, and other essential tasks

In addition to performing emergency protective actions and bringing the situation under control, it is necessary to carry out actions to mitigate consequences and other essential tasks in the area affected by the nuclear or radiological emergency. Examples of these include security and access control, radiological survey and other measurement activities, essential social and health services and maintenance of society's critical infrastructure, such as electricity, food and water supply.

Persons performing such work in the affected area are emergency helpers and are subject to the restrictions and principles described in section 2.3.1.

2.3.3 Protection of emergency workers and helpers and assessment of their radiation exposure

Emergency workers and helpers should wear protective clothing and carry respirators and, if necessary, iodine tablets when entering a contaminated or potentially contaminated area. Emergency workers and helpers may be exposed to such a significant amount of iodine that, unlike the general public, iodine tablets should be taken regardless of age. Table II provides indicative operational intervention levels and guidelines for the protection of workers.

The anticipated level of exposure must be assessed before commencing a task, and a plan must be made as to how dose accumulation will be monitored during the work. Unless personal dosimeters are in use, the dose from external radiation shall be assessed based on the external radiation dose rate.

Table III provides examples of dose accumulation when exposed to external radiation. In addition, the dose is accumulated through the inhalation of radioactive material into the body and, possibly, through radioactive contamination of the skin. It is important to record the working hours in the contaminated area and the location data and information on the radiation level in the area if a radiation meter is available.

Annex 6 details the properties of the personal protective equipment.

TABLE II. Protection of emergency workers and helpers.

Indicative operational intervention level	Protection of workers
• the external dose rate is or is anticipated to be 10–100 μSv/h or • the airborne concentration of radioactive material is or is anticipated to be as follows: • alpha emitters 0.1–1 Bq/m³ • beta emitters 100–1,000 Bq/m³ • caesium-137 and other strong gamma emitters in total 1,000–10,000 Bq/m³	• workers shall wear dust-proof protective clothing and respirators when in a contaminated area or area that may be contaminated • workers shall take an iodine tablet if the air may contain radioactive iodine. Note! If an iodine tablet has been taken within the past 24 hours, a second iodine tablet must not be taken. • working hours and location details are recorded as accurately as possible • if a dose rate meter is used, the external radiation dose rate is recorded regularly; for example, every hour • if personal or group-specific dosimeters are available, they shall be used in accordance with the instructions
• the external dose rate is or is anticipated to be 100–1,000 μSv/h or • the airborne concentration of radioactive material is or is anticipated to be as follows: • alpha emitters 1–10 Bq/m³ • beta emitters 1,000– 10,000 Bq/m³ • caesium-137 and other strong gamma emitters in total 10,000–100,000 Bq/m³	• workers shall wear dust-proof protective clothing and respirators when in a contaminated area or area that may be contaminated • workers shall take an iodine tablet if the air may contain radioactive iodine. **Note!** If an iodine tablet has been taken within the past 24 hours, a second iodine tablet must not be taken. • working hours and location details are recorded as accurately as possible • if a dose rate meter is used, the external radiation dose rate is recorded regularly; for example, every hour • if personal or group-specific dosimeters are available, they shall be used in accordance with the instructions • if the situation prolongs, the total working time of the workers shall be limited by shift work arrangements if necessary.
• the external dose rate is or is anticipated to be 1,000–10,000 μSv/h or • the airborne concentration of radioactive material is or is anticipated to be as follows: • alpha emitters 10–100 Bq/m³ • beta emitters 10,000– 100,000 Bq/m³ • caesium-137 and other strong gamma emitters in total 100,000–1,000,000 Bq/m³	• staying in a contaminated area or area that is likely to be contaminated is limited where possible without impeding urgent protective actions; workers shall use dust-proof protective clothing and respirators • working hours and location details are recorded as accurately as possible • workers shall take an iodine tablet if the air may contain radioactive iodine. Note! If an iodine tablet has been taken within the past 24 hours, a second iodine tablet must not be taken. • if a dose rate meter is used, the external radiation dose rate in different work areas shall be recorded regularly • if personal or group-specific dosimeters are available, they shall be used in accordance with the instructions • the total working time of the workers shall be limited by shift work arrangements if necessary • Note: for example, radiation surveys and other outside measurement activities involving worker exposure shall be stopped.

• the external dose rate exceeds or is anticipated to exceed 10,000 µSv/h
 	
or
 	
• the concentration of radioactive material in the air exceeds or is anticipated to exceed one of the following:
  • alpha emitters 100 Bq/m^3
  • beta emitters 100,000 Bq/m^3
  • caesium-137 and other strong gamma emitters in total 1,000,000 Bq/m^3
	• only work which is absolutely necessary to ensure the safety of the public is conducted
	• work shifts are limited by work shift arrangements; if possible, the annual worker dose is limited to 20 mSv.
	• working hours and location details are recorded as accurately as possible
	• workers shall wear dust-proof protective clothing and respirators
	• workers shall take an iodine tablet if the air may contain radioactive iodine. Note! If an iodine tablet has been taken within the past 24 hours, a second iodine tablet must not be taken.
	• if a dose rate meter is used, the external radiation dose rate in different in- and outdoor work areas shall be recorded regularly
	• if personal or group-specific dosimeters are available, they shall be used in accordance with the instructions.

TABLE III. Examples of radiation dose accumulation when exposure is solely due to external radiation.

External radiation dose rate in the area	20 mSv is exceed-ed
100 µSv/h = 0.1 mSv/h	in 200 hours
1,000 µSv/h = 1 mSv/h	in 20 hours
10,000 µSv/h = 10 mSv/h	in 2 hours

2.3.4 Other workers in the area affected by a nuclear or radiological emergency

Workers not involved in urgent or other essential tasks are subject to reference values applied to members of the public (1.4.2). Such workers include, for example, people who are required to enter an area under sheltering indoors to care for production animals. The workers must be instructed on how to protect themselves during the work.

2.4 Protection of foodstuffs, household water and animal feed in the early phase

2.4.1 Protection of foodstuffs, household water and animal feed production

Primary food production includes, for example, milk and egg production, beef raising, fish farming and vegetable, fruit, cereal and mushroom growing. The protection of primary food production aims to keep radioactive material levels in foodstuffs below the concentration limits set out in chapter 3.3.

Protection of primary production of foodstuffs and feeds

In the event of a nuclear or radiological emergency, protection of primary food and animal feed production should be initiated as soon as possible. Radioactive iodine, for example, is rapidly transferred into milk if the cattle are fed contaminated feed. Even if the external radiation dose rate does not rise much above the normal prevailing radiation level, foodstuffs may end up containing enough radioactive material to exceed the maximum levels of radioactive material in foodstuffs, preventing them from being placed on the market.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR THE PROTECTION OF PRIMARY FOOD PRODUCTION:

– the external dose rate exceeds or is anticipated to exceed 1 μSv/h

or

– the concentration of radioactive material in the air exceeds or is anticipated to exceed one of the following:
- alpha emitters 0.1 Bq/m^3 (plutonium-239 and americium-241)[3],
- beta emitters 10 Bq/m^3 (strontium-90),
- caesium-137, iodine-131 and other heavy gamma emitters in total 100 Bq/m^3

For the protection of farmed animals, it is essential to ensure access to clean feed and drinking water and to keep the animals indoors if possible. The protection of the stored feed must be ensured. Fresh feed growing on fields should also be harvested and protected with, for example, plastic coating if the season allows for it. Other possible measures include shutting off or restricting the ventilation of animal shelters if this can be done without compromising animal welfare. Where possible, the ventilation of greenhouses, grain silos and the like should be shut off or restricted.

3 The fact that only very small amounts of alpha emitters are transferred to foodstuffs has been considered

Cultivated land and crops for own consumption, e.g. kitchen gardens, are covered to prevent their contamination. Covering should be carried out where feasible considering the season and extent of cultivations.

Rainwater collected during a nuclear or radiological emergency must not be used as drinking water for animals or for irrigation. If possible, the use of water from small ponds and streams as drinking water for animals or for irrigation of crops must also be avoided.

Food raw materials stored outside, such as harvested sugar beet, should be protected whenever feasible before the arrival of the radioactive plume. Unprotected raw materials must not be used before their safety is confirmed by measurements. The safety of food packaging materials must also be ensured before use.

Measures concerning food and animal feed production facilities, logistics centres and water treatment plants

Food and feed production facilities and logistics centres may be contaminated in the same manner as other indoor areas. Therefore, it is important to shut off their ventilation and, if possible, suspend production until the outdoor air is clean. This reduces the contamination of the facilities, production equipment and foodstuffs.

To ensure the cleanliness of household water, water treatment plants must shut off their ventilation. If the plant uses aeration for water treatment, the aeration process is bypassed. Water towers must ensure the cleanliness of household water by avoiding water level fluctuation to reduce the introduction of contaminated air into the tower. For example, to keep the water level in the water tower as stable as possible, the public should not be instructed to store household water in containers during sheltering indoors.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR THE PROTECTION OF INDOOR AREAS:

– the external dose rate exceeds or is anticipated to exceed 10 µSv/h

or

– the concentration of radioactive material in the air exceeds or is anticipated to exceed one of the following:

- alpha emitters 0.1 Bq/m^3 (plutonium-239 and americium-241),
- beta emitters 100 Bq/m^3 (strontium-90),
- caesium-137, iodine-131 and other heavy gamma emitters in total 1,000 Bq/m^3

2.4.2 Restrictions on trade and use of foodstuffs

In the case of a nuclear or radiological emergency, it is important that contaminated foodstuffs are not used or placed on the market. Therefore, it may be necessary to set a temporary sales ban on foodstuff and other natural goods from areas which are known or anticipated to be contaminated during the emergency. The temporary sales ban will be lifted as soon as the safety of the foodstuffs is confirmed.

Priority must be given to preventing contamination of foodstuffs. Packaged foodstuffs and foodstuffs stored in hermetically sealed cabinets and rooms will remain clean. The contamination of unprotected foodstuffs in indoor areas will be significantly reduced if the ventilation can be shut off.

Once contamination of the environment is deemed probable or imminent, the EU Commission can issue maximum permitted concentration limits of radioactive contamination agreed in advance for radioactive material in foodstuffs and household water. Compliance with the concentration limits for food and household water will reduce radiation exposure through foodstuffs. If the concentration limits are not exceeded, there is no radiation protection-related reason preventing international trade in products and goods. The limits are presented in chapter 3.3.

If the emergency involves a risk of foodstuffs containing radioactive material being placed on the market, concentration limits may need to be observed even before the Commission's decision. This can be achieved by temporarily implementing the concentration limits at the national level, even with limited details of the emergency.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR A TEMPORARY SALES AND USE BAN OF FOODSTUFFS AND NATURAL PRODUCTS:

– the external dose rate exceeds or is anticipated to exceed 10 μSv/h

or

– the concentration of radioactive material in the air exceeds or is anticipated to exceed one of the following:

- alpha emitters 1 Bq/m^3 (plutonium-239 and americium-241)[4],
- beta emitters 100 Bq/m^3 (strontium-90),
- caesium-137, iodine-131 and other heavy gamma and beta emitters in total 1,000 Bq/m^3

2.5 Protection of other raw materials and products

2.5.1 Protection of raw materials and finished products

Raw materials and other unprotected products in outdoor areas may be contaminated during a nuclear or radiological emergency. Therefore, they should be protected before the arrival of the radioactive plume whenever it can be done at a reasonable cost. Raw materials and products in packages will remain clean. The contamination of raw materials and products stored in indoor areas will be significantly reduced if the ventilation can be shut off. Unprotected materials or products may not be used before their safety is confirmed by measurements.

4 The fact that only very small amounts of alpha emitters are transferred to foodstuffs has been considered

2.5.2 Protection of production facilities

Production facilities may be contaminated in the same manner as other indoor areas. To facilitate the effective continuation of operation in the facilities after the emergency, it is important to shut off their ventilation and, if possible, suspend production until the outdoor air is clean. This reduces the contamination of the facilities, production equipment and products and, thereby, the need for large-scale decontamination operations.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR THE PROTECTION OF RAW MATERIALS, PRODUCTS AND PRODUCTION FACILITIES:

– the external dose rate exceeds or is anticipated to exceed 10 µSv/h

or

– the concentration of radioactive material in the air exceeds or is anticipated to exceed one of the following:

- alpha emitters 0.1 Bq/m^3 (plutonium-239 and americium-241)
- beta emitters 100 Bq/m^3 (strontium-90)
- caesium-137, iodine-131 and other strong gamma and beta emitters in total 1,000 Bq/m^3.

3. Protective actions in the intermediate phase of a nuclear or radiological emergency

3.1 Actions to protect members of the public in the intermediate phase

3.1.1 Sheltering indoors and continuing sheltering indoors

Sheltering indoors in the intermediate phase of a nuclear or radiological emergency reduces the fallout exposure and contamination of people and indoor areas. If the public is not sheltering indoors in an area where the criteria for sheltering indoors are found to be exceeded, sheltering indoors shall be initiated in the intermediate phase. This may be necessary, for example, if measurements indicate that the area is more contaminated than anticipated. If sheltering indoors has been implemented in the early phase, it shall be continued as long as the respective criteria are exceeded.

The total duration of sheltering indoors should not exceed two days. Otherwise, non-radiation-related issues, such as problems with access to food and medicines, will increase rapidly. Also, the protection level is significantly reduced if sheltering indoors becomes prolonged (see Annex 3). If the radiation level after two days is still so high that sheltering indoors cannot be lifted or changed to partial sheltering indoors, members of the public must be evacuated from the area in question (chapter 3.1.7). In this case, the public needs instructions on how to prepare for the evacuation arrangements and carry out necessary activities that require going outdoors. Determining the time to transition from or lift sheltering indoors shall consider information on the released radioactive material, the prevailing radiation situation, the forecast of the evolution of the situation, and how long the sheltering indoors has already lasted.

DOSE CRITERION FOR SHELTERING INDOORS:

The projected radiation dose to an unprotected person in two days exceeds 10 mSv.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR SHELTERING INDOORS IN THE INTERMEDIATE PHASE:

– the external radiation dose rate exceeds 100 μSv/h

or

– the total deposition of strong gamma and beta emitters exceeds 10,000,000 Bq/m^2,

or

– the deposition of alpha emitters exceeds 100,000 Bq/m^2, assuming that the alpha emitters are in the non-fixed form on the surface.

3.1.2 Partial sheltering indoors and continuing partial sheltering indoors

It is possible to spend time outdoors during the restriction, but it must be limited to the minimum necessary. The measure is required when there are radioactive materials in the environment, but not to the extent of making strict sheltering indoors necessary. It is especially important to minimise the time children and pregnant women stay outdoors. Unlike in the early phase, normal ventilation should be kept on in the intermediate phase, as there are no longer radioactive materials in the outdoor air.

When the criteria for sheltering indoors are no longer met, it is possible to transition to partial sheltering indoors (chapter 3.1.1). It may also be necessary to initiate partial sheltering indoors in the intermediate phase if measurements indicate that the area is more contaminated than previously anticipated.

Indoor areas should be carefully ventilated and cleaned immediately after a transition from sheltering indoors to partial sheltering indoors (see chapter 3.2.1). It should also be ensured not to bring radioactive material into the environment indoors on the shoes of people coming in from outdoors, for example.

DOSE CRITERION FOR PARTIAL SHELTERING INDOORS AND TRANSITION FROM SHELTERING INDOORS TO PARTIAL SHELTERING INDOORS:

The projected radiation dose to an unprotected person in the first month exceeds 10 mSv but is less than 10 mSv during two days.

INDICATIVE OPERATIONAL INTERVENTION LEVEL FOR PARTIAL SHELTERING INDOORS AND TRANSITION FROM SHELTERING INDOORS TO PARTIAL SHELTERING INDOORS:

– the external dose rate is less than 100 μSv/h but greater than 10 μSv/h

or

– the total deposition of strong gamma and beta emitters is 1,000,000–10,000,000 Bq/m^2,

or

– the deposition of alpha emitters is higher than 10,000–100,000 Bq/m^2, and the radioactive material may be in non-fixed form.

To reduce unnecessary exposure of the public to radioactive material in the environment, the authorities need to provide instructions on how to carry out necessary activities that require going outdoors. Important activities of society, such as the grocery shops and essential public transport services, can be introduced during partial sheltering indoors, along with environmental clean-up measures (see chapter 3.2.1). If the living environment's radiation level does not decrease rapidly despite radioactive decay and decontamination measures, the evacuation of members of the public should be considered (see chapter 3.1.7).

3.1.3 Lifting of sheltering indoors and partial sheltering indoors

Sheltering indoors and partial sheltering indoors may be lifted when radiation levels have fallen below the criteria for the respective measures. Also, it must be ensured that the radiation exposure of the public decreases significantly during the first month or that it can be effectively reduced by decontamination of the living environment. If the environmental contamination does not allow for a decrease in exposure within the first few months, even with decontamination measures, the evacuation of members of the public should be considered (chapter 3.1.7).
Several other measures to reduce exposure may be required when lifting sheltering indoors. These measures and their rationale are described in chapters 3.1.8 and 3.2.1.

DOSE CRITERION FOR LIFTING PARTIAL SHELTERING INDOORS:

– The projected radiation dose to an unprotected person in a month is less than 10 mSv.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR LIFTING PARTIAL SHELTERING INDOORS:

– The external dose rate is lower than 10 μSv/h,

or

– the deposition of strong gamma and beta emitters is less than 1,000,000 Bq/m^2,

or

– the deposition of alpha emitters is less than 10,000 Bq/m^2.

3.1.4 Access restrictions in the intermediate phase

Access restrictions refer to measures that restrict access to the hazardous area other than for essential tasks. Access restrictions apply to road, rail and waterborne traffic and airports. Access restrictions may have been needed already in the early phase. The restrictions shall be further specified as more detailed information on the fallout situation becomes available.

ACCESS RESTRICTION CRITERIA:

Areas under sheltering indoors (3.1.3) or evacuation orders (3.1.7) should be imposed with simultaneous access restrictions.

Access restricted areas may be entered only to carry out essential tasks related, for example, to rescue services, food supply and other vital activities of society or urgent decontamination, evacuation and accident management activities. Residence time in the area should be restricted to an absolute minimum. Monitoring and decontamination of vehicles and people leaving the area must be arranged.

Essential passage through the contaminated area is an exception to the foregoing. In the case of rail transport, alternative routes may not be available. The passage must be planned so that it can be carried out as quickly as possible. Also, provisions must be made for contamination monitoring and, if necessary, decontamination of the vehicles. Transport by waterways is preferable to other forms of transport since external dose rates are very low in water areas, even when the surrounding land areas are heavily contaminated. Decontaminated road areas can be used for essential transport even if they pass through the hazardous area. The operation of ships, trains and aircraft in areas where they may be contaminated should be planned carefully, as their decontamination requires more provisions and special decontamination points compared to other vehicles.

In areas undergoing a transition from sheltering indoors to partial sheltering indoors, a simultaneous transition from access restrictions to traffic control (3.1.5) is advised.

3.1.5 Traffic control in a precautionary area in the intermediate phase

In a precautionary area with partial sheltering indoors in force, traffic should be directed to decontaminated routes. The efforts to launch important activities and services of society, such as health care, grocery shops and essential public transport services, require moving about the area. In this case, traffic is directed to routes along which monitoring and decontamination points can be arranged (decontamination of people: chapter 3.1.10; decontamination points: chapter 3.2.1). The above also applies to airports, harbours and border crossing points.

CRITERION FOR A TRANSITION FROM ACCESS RESTRICTIONS TO TRAFFIC CONTROL:
In areas undergoing a transition from sheltering indoors to partial sheltering indoors (3.1.2), a simultaneous transition from access restrictions to traffic control is advised.

CRITERION FOR TRAFFIC CONTROL:
Areas under a partial sheltering indoors order (3.1.2) should implement simultaneous traffic control.

3.1.6 Lifting access restrictions and traffic control

Access restrictions, traffic control and decontamination points are no longer needed after the termination of the sheltering indoors and partial sheltering indoors.

CRITERION FOR LIFTING ACCESS RESTRICTIONS AND TRAFFIC CONTROL:
In areas where sheltering indoors and partial sheltering indoors (3.1.3) are lifted, access restrictions and traffic control should be lifted simultaneously.

3.1.7 Evacuation in the intermediate phase

About evacuation

Evacuation of the public means the moving of the population or part of the population from the contaminated area under the direction of the authorities or independently in accordance with appropriate instructions to a safe area. The concept of evacuation does not include people moving away on their own initiative. However, people's moving away on their own initiative from an area deemed to be dangerous must be considered in emergency response plans, including the provision of assembly points.

Evacuation is a general concept which includes a range of actions of varying duration. For the purposes of this guide, evacuation is divided into protective evacuation (see 2.1.4), temporary relocation lasting from a few months to about two years, and permanent relocation, meaning evacuation in a situation where it is presumed that the area cannot be restored to a habitable condition.

The aim is to keep the relocation of people as short as possible. The evacuated areas are to be decontaminated as quickly as possible. Besides the radiation situation, other factors and social conditions also affect the decision to remove all or some members of the public from a contaminated area for a long period of time or permanently.

Evacuation is carried out in a systematic manner to protect people from contamination as much as possible. Evacuees must be instructed on the items they should take with them. They must also be instructed on the condition in which the dwelling should be left. Evacuated people must be moved far enough to an area where protective actions are not required.

The evacuation of high-risk and demanding sites, such as hospitals and care facilities, may require special arrangements. Such sites must be considered separately when making evacuation decisions and arrangements. It may be necessary to continue sheltering indoors in high-risk sites in the evacuated area until their evacuation can be arranged safely and in a controlled manner.

Where necessary, evacuations shall be supplemented by other relocation measures, such as the relocation of farmed animals, facilities and organisations of trade and industry. The maintenance of the important infrastructure (such as electricity, water and sewerage networks) and farm animals remaining in the evacuated areas during a short-term evacuation or temporary relocation must be ensured. Pets must be evacuated with the people or their well-being in the evacuated areas ensured.

Both short-term evacuations and long-term relocations, in particular, have a strong impact on people's lives, something that must be taken into account when deciding on them. Instead of relocation, living, trade and industry in the contaminated area may be continued after carefully targeted decontamination actions and restrictions on use and by ensuring the availability of essential services in the area. However, it may be appropriate to carry out a short-term evacuation while the area is decontaminated.

Evacuation

Evacuation may also be carried out even before meeting the criteria, provided that it can be done easily and quickly, for example, when a small group of people is concerned. Relaxing the criteria may be appropriate in cases where evacuation is difficult due to, for example, the large number of people to be evacuated or lack of transportation capacity. In such cases, evacuation can be carried out partially, focusing on certain groups of people, such as families with children and pregnant women.

DOSE CRITERION FOR EVACUATION:

The projected radiation dose to an unprotected person accumulated in the first week exceeds 20 mSv.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR EVACUATION:

If the following radiation levels are exceeded for more than two days:

– the external radiation dose rate exceeds 100 μSv/h,
or
– the total deposition of strong gamma and beta emitters exceeds 10,000,000 Bq/m^2,
or
– the deposition of alpha emitters exceeds 100,000 Bq/m^2, assuming that the alpha emitters are in the non-fixed form on the surface.

Temporary relocation and permanent relocation

Temporary and permanent relocations and their duration shall be based both on the radiation exposure from a measured fallout and societal, psychological and economic considerations, etc. Resettlement entails significant costs and other issues related to, for example, the organisation and/or construction of housing, schools, health care, jobs and other infrastructure.

In the case of a nuclear or radiological emergency, a short-term evacuation may lead to longer-lasting temporary relocation or permanent relocation of the members of the public to uncontaminated areas if it turns out that radiation levels in the evacuated areas do not decrease to an acceptable level quickly enough.

The duration of a **temporary relocation** may vary from a few months to approximately two years. Temporary relocation may also be started weeks after the beginning of the hazardous situation, even if the radiation situation has not previously required evacuation. In this case, the exposure in the first few weeks has not been high enough to require evacuation (chapter 2.1.4), but the accumulated doses during long-term exposure would be significant. Temporary relocation should be considered if the projected dose to an unprotected person exceeds 10 mSv in one month despite decontamination of the area.

DOSE CRITERION FOR TEMPORARY RELOCATION:

The projected radiation dose to an unprotected person exceeds 10 mSv in one day after the first month.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR TEMPORARY RELOCATION:

– the average external dose rate in the living environment exceeds 10 μSv/h despite decontamination of the area,

or

– the deposition of strong gamma and beta emitters in the living environment exceeds 1,000,000 Bq/m^2 despite decontamination of the area,

or

– the deposition of alpha emitters in the living environment exceeds 10,000 Bq/m^2 despite decontamination of the area, and the emitters are located on material surfaces from which they can enter the inhaled air (e.g. sand surface).

A **permanent relocation** is required in a situation where it is expected that the radiation level in the area cannot be permanently brought down to an acceptable level. Resettlement is necessary if the dose criterion is estimated to be exceeded. Permanent relocation is also necessary if the projected radiation dose from the emergency over several decades exceeds 1,000 mSv. This is the case, for example, if the external dose rate is permanently at or above 2 μSv/h during a lifetime.

DOSE CRITERION FOR PERMANENT RELOCATION:

The projected annual radiation dose to an unprotected person exceeds 50 mSv after more than one year from the emergency.

Lifting of evacuation or temporary relocation

Evacuation or temporary relocation can be lifted, and the public return to the area when the projected radiation dose to an unprotected person is less than 10 mSv in the first month after return and the dose is expected to decrease rapidly due to, for example, decontamination measures or radioactive decay. However, it should still be ensured that the annual dose will remain below 20 mSv when considering all the protective actions, such as environmental clean-up measures.

DOSE CRITERION FOR A LIFTING OF EVACUATION OR TEMPORARY RELOCATION:
the projected radiation dose to an unprotected person is less than 10 mSv in the first month after return and less than 20 mSv in the whole year.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR THE LIFTING OF EVACUATION OR TEMPORARY RELOCATION:

– the average external radiation dose rate in the living environment is less than 10 µSv/h and is expected to decrease rapidly,
  or
– the total deposition of strong gamma and beta emitters in the living environment is significantly less than 1,000,000 Bq/m^2 and will decrease rapidly,
  or
– the deposition of alpha emitters in the living environment is less than 10,000 Bq/m^2 and will decrease rapidly.

3.1.8 Self-reduction of exposure

Individuals in contaminated areas can reduce their exposure themselves at homes, workplaces and other premises. Besides homes, attention should be paid to public areas, in particular daycare centres, schools and other places for children and young people.

Careful washing reduces the amount of radioactive material on the skin or hair. Frequent washing of hands is especially important to prevent the transfer of radioactive material to the mouth from contaminated hands. Clothes, including indoor clothing, should be washed more frequently than normal. More detailed instructions should be provided to the public during the emergency. Annex 7 contains examples of exposure reduction measures. Human exposure can also be reduced through careful cleaning of indoor areas. Cleaning of indoor areas is discussed in chapter 3.2.1.

3.1.9 Protection of workers and people outdoors in the contaminated area

Actions for mitigating the consequences of the accident, and other essential work

In the intermediate phase, there is usually no need to implement urgent protective actions that would expose emergency workers or helpers to a dose in excess of 20 mSv. An exception to this may be, for example, an accident involving a radiation source or an intentional act causing an emergency without an early phase or with only a very short early phase. The radiation protection of workers related to urgent protective actions is discussed in chapter 2.3.

Workers involved in the intermediate phase's protective actions, actions for mitigating the consequences of an accident or other essential work may be more exposed to radiation than members of the public. People carrying out such work are emergency workers or helpers also in the intermediate phase, and their radiation protection shall be subject to the instructions provided in chapter 2.3.

Actions for mitigating the consequences of the accident in the intermediate phase include, for example, decontamination of indoor areas and the environment, repair and decontamination of the accident facility and buildings, guarding of the contaminated area, access control in the access-restricted area, radiological survey and other measurement activities and treatment and disposal of decontamination waste.

Other necessary work include, for example, the organisation of social and health care services and the maintenance of order and other critical infrastructure of society, such as electricity, food and water supply.

The measures, especially the more extensive decontamination measures, may continue after a Government decision on the termination of the emergency exposure situation (Radiation Act, Section 137). The decision marks the transition to the recovery phase. In this case, for example, individuals carrying out decontamination measures are subject to worker provisions applied in normal conditions. Individuals who may receive an annual dose of more than 1 mSv performing said work are radiation workers pursuant to the Radiation Act.

Other work in a contaminated area

From the radiation protection viewpoint, individuals who are not emergency workers or helpers but practice their own profession in a contaminated area are considered members of the public during a nuclear or radiological emergency. Measures should be taken to limit the exposure of such individuals in the contaminated area.

Radiation exposure of workers may be from radioactive material in the working environment (e.g. peat production and wastewater treatment plants) or from contaminated raw materials, products, vehicles or machinery. Exposure is also affected by the working methods used, such as the level of dust involved.

It is primarily the responsibility of the employer to limit exposure by decontaminating the working environment. It is important to identify the work steps and methods that cause the most exposure and target decontamination and other activities accordingly.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR THE REDUCTION OF WORKER EXPOSURE:

– the external dose rate in the working environment is higher than 10 µSv/h,
  or
– the surface contamination from strong gamma and beta emitters exceeds 1,000,000 Bq/m^2,
  or
– the contamination from alpha emitters exceeds 10,000 Bq/m^2, provided the alpha emitters on the material surfaces may be in non-fixed form.

The decontamination and other measures to reduce the exposure of workers aim to decrease the dose from the deposition as quickly as possible to as low as reasonably achievable.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR LIFTING MEASURES TO REDUCE WORKER EXPOSURE:

– the external dose rate in the working environment is less than 1 µSv/h,
  or
– the surface contamination from strong gamma and beta emitters in the working environment is less than 100,000 Bq/m^2,
  or
– the surface contamination from alpha emitters in the working environment is less than 1,000 Bq/m^2, provided the alpha emitters on the material surfaces may be in non-fixed form.

Decontamination measures should also be continued below the above values if they prove effective in further reducing the dose. Decontamination of the living environment is discussed in chapter 3.2.1, and waste treatment in chapter 3.4.

Examples of practical measures to limit worker exposure:

- reducing radioactive material in the inhaled air by limiting dust generation, for example, by wetting dusty surfaces
- wearing protective clothing and respirators if at risk of inhaling radioactive dust while working
- careful cleaning of the skin by washing after work
- changing of protective clothing and washing (skin and equipment) to prevent contamination from spreading into clean workplaces and working areas
- moving material and waste containing radioactive material to a place away from the immediate vicinity of places of work or minimising work periods in the vicinity of material and waste containing radioactive material
- rescheduling the work to a time after the decontamination of the area, if possible
- if material or waste containing radioactive material cannot be moved away from working areas, providing radiation-absorbing structures or other shields between the material or waste and the worker
- restricting or dividing the working hours into sections.

Exposure may also be limited by postponing the work. If the work can be carried out later without it causing significant detriment (e.g. felling of trees), the work should be postponed to a later date when the exposure from external radiation and the amount of radioactive material in the working environment has decreased.

3.1.10 Decontamination of people and clothing

People can be contaminated in the early phase of the emergency from radioactive material in the air or later from deposition on the ground and surfaces. Contamination of a person can only be detected by radiation monitoring. The purpose of radiation monitoring in the intermediate phase is to locate and identify persons who are in need of decontamination measures or treatment. In the longer term, people monitoring may be required to identify individuals who are in justifiable need of long-term health surveillance.

Contaminated people must be decontaminated to reduce their radiation dose. This also prevents the spread of radioactive material to non-contaminated areas and other people.

Determining contaminated people may require a comprehensive monitoring programme. In case of an extensive fallout situation, the authorities must be prepared for a great many people who are afraid of being contaminated and are very concerned about their health.

Monitoring people

As a rule, those people who are suspected most contaminated are monitored first. However, monitoring should ideally be arranged for everybody who wants to be measured and may have been in a contaminated area. Radiation monitoring is also needed in connection with the decontamination points to ensure that the decontamination is carried out sufficiently efficiently.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR THE ARRANGEMENT OF MONITORING AND DECONTAMINATION OF PEOPLE RESIDING IN THE AREA:

– the external radiation dose rate in the environment is higher than 10 μSv/h,

or

– the surface contamination from strong gamma and beta emitters exceeds 1,000,000 Bq/m^2,

or

– the contamination from alpha emitters exceeds 10,000 Bq/m^2, provided the alpha emitters on the material surfaces may be in non-fixed form.

Radiation monitoring and decontamination facilities must be arranged in a suitable location (e.g. washroom in a public indoor swimming pool, sports hall or school) near a border between the contaminated and clean area. Appropriate radiation monitoring and decontamination facilities and opportunities shall be arranged for people who are moving from a contaminated area to a less contaminated area Where necessary, the same shall apply to people living within the area. Personal data of the contaminated individuals and their radiation monitoring results must be recorded.

Monitoring instructions are presented in Annex 8.

Decontamination of people

The primary method to remove radioactive material from the human skin and hair is by washing. Decontamination of people is always necessary when a radiation survey meter indicates a dose rate near the skin that is higher than the prevailing dose rate at the monitoring site. If possible, the monitoring shall be carried out in a clean or as low-contaminated area as possible. Measurements shall be made as close as possible to the monitored object without touching it.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR SELF-WASHING:

– the external radiation dose rate near the skin exceeds the prevailing dose rate at the monitoring site but not by more than 0.5 μSv/h,

or

– if a contamination meter measurement indicates that the amount of strong gamma or beta emitters on the skin exceeds 2 Bq/cm² but is less than 1,000 Bq/cm²,

or

– if a contamination meter measurement indicates that the amount of alpha emitters on the skin exceeds 0.2 Bq/cm² but is less than 100 Bq/cm².

If the monitoring result of a person exceeds the background radiation of the monitoring site, the topmost layer of clothing is removed, and the measurement is repeated. If the second measurement does not exceed 0.5 μSv/h, the person is provided with instructions for self-washing and how to clean their clothes and clean or dispose of other accessories. If the exceedance is greater than 0.5 μSv/h, the person is directed to a designated wash place in, for example, a sports hall or public indoor swimming pool, where they can be remeasured after decontamination.

INDICATIVE OPERATIONAL INTERVENTION LEVELS TO DIRECT A PERSON TO A DESIGNATED WASH PLACE:

– if the external dose rate measured near the skin exceeds the prevailing dose rate at the monitoring site by more than 0.5 μSv/h,

or

– if a contamination meter measurement indicates that the amount of strong gamma or beta emitters on the skin exceeds 1,000 Bq/cm²,

or

– if a contamination meter measurement indicates that the amount of alpha emitters on the skin exceeds 100 Bq/cm².

After washing up at a designated wash place, the measurement and, if necessary, the washing are repeated. Decontamination can be stopped when it no longer reduces the dose rate, as verified by measurements. If the dose rate does not fall below 1 μSv/h despite decontamination, the nature of the contamination should be determined, such as if it is internal. The amount and quality of internal exposure and the person's possible need for care are assessed using excreta and whole-body measurements made according to the instructions provided by the Radiation and Nuclear Safety Authority.

Severely contaminated individuals shall be decontaminated as described above and subsequently sent for further examination to carry out health impact assessment and possible additional decontamination. Very serious contamination increases the risk of skin damage. It also significantly increases the risk of internal exposure, i.e. the transfer of radioactive material to the mouth from contaminated hands.

INDICATIVE OPERATIONAL INTERVENTION LEVELS TO SEND A PERSON FOR FURTHER EXAMINATION:

– if the external dose rate measured near the skin exceeds the prevailing dose rate at the monitoring site by more than 2 μSv/h,

or

– if a special meter measurement indicates that the amount of alpha emitters on the skin exceeds 1,000 Bq/cm^2 or strong gamma or beta emitters exceed 10,000 Bq/cm^2 prior to decontamination

For example, if the strontium-90 level on the skin was to exceed 10,000 Bq/cm^2, the resulting skin dose would exceed the annual dose limit (50 mSv) for the public in two hours. It is likely that people could only be seriously contaminated at the scene of the accident, like the firefighters extinguishing the Chernobyl reactor fire or some workers at the Fukushima accident facility or if radioactive material from a radiation source is outside the shield and comes into direct contact with the skin. Severely contaminated people with a possible total dose in excess of 100 mSv shall be offered long-term medical surveillance.

If urgent hospital treatment is necessary due to another injury or illness, a contaminated patient can be sent to the hospital without prior decontamination. If possible, from the treatment point of view, the patient shall be, for example, wrapped in a blanket to prevent contamination of the ambulance. The hospital must be informed of the arrival of a contaminated patient. Even serious contamination does not prevent the treatment of the patient.

Thyroid monitoring is required to assess the thyroid dose received. Starting thyroid monitoring should be considered in an area where the concentration of iodine-131 in the air exceeds 1,000 Bq/m^3. Due to the short half-life of iodine-131, measurements should be made as soon as possible and, in any case, no later than one month after exposure to be able to assess the exposure. If the dose rate measured at the thyroid gland exceeds the prevailing dose rate at the monitoring site by more than 0.5 μSv/h, the person in question should be referred to more specific monitoring. Annex 8 describes how thyroid monitoring is performed.

INDICATIVE OPERATIONAL INTERVENTION LEVEL FOR PROVIDING THYROID MONITORING:

– The iodine-131 concentration in the air exceeds 1,000 Bq/m^3.

INDICATIVE OPERATIONAL INTERVENTION LEVEL TO SEND A PERSON FOR FURTHER EXAMINATION OF THYROID GLAND EXPOSURE:

– The external dose rate measured at the thyroid gland exceeds the prevailing dose rate at the monitoring site by more than 0.5 μSv/h.

Managing contaminated items of clothing

Contaminated clothes and footwear cause exposure to the wearer and can spread radioactive material into clean areas. Contaminated clothing is measured separately from the people:

- If the external radiation dose rate measured from the surface of the items of clothing is 0.5–10 μSv/h above the prevailing external radiation dose rate at the monitoring site, contaminated items must be washed or thoroughly cleaned before being put back into service. The washing water is directed to the public sewer network.
- If the external radiation dose rate measured from the surface of the items of clothing exceeds 10 μSv/h, the items must be immediately sealed in plastic bags for subsequent cleaning or disposal. Therefore, a clean change of clothes and footwear should be provided at the decontamination points.

3.2 Measures concerning the living environment

The objective of the decontamination measures in the intermediate phase and other actions to reduce exposure is to keep the dose to an individual from the fallout in the living environment below 10 mSv in the first year and that the exposure in the following years can be reduced to a minimum as quickly as possible. However, the individual intervention levels provided in this chapter do not necessarily guarantee that the exposure due to contamination in the living environment will remain below 10 mSv.

The living environment comprises the built, cultivated and natural environment. Built environment refers to, for example, residential and business areas, industrial areas and road, harbour, airport and warehouse areas, parks, playgrounds and other developed outdoor areas (e.g. golf courses, ski resorts, camping areas, public beaches). Natural environment refers to, for example, forests, marshlands, natural meadows, open rock and stony areas and bodies of water. Cultivated environment refers to fields, vegetable patches and pastures.

When assessing the radiation dose from the living environment, the exposure received both indoors and outdoors is considered. However, exposure from contaminated food or received in the early phase of a nuclear or radiological emergency shall not be included in the dose assessment.

Measures concerning the cultivated environment are provided in chapter 3.3 on measures concerning foodstuffs.

The treatment of radioactive waste from decontamination is described in chapter 3.4.

3.2.1 Decontamination and other measures to limit exposure

Decontamination measures required in the intermediate phase of a nuclear or radiological emergency may vary. The content of appropriate and effective decontamination measures depends, for example, on the radioactive material dispersed, time of year and the type of the contaminated area. A plan must be drawn up on the decontamination measures, including the regional and temporal details of their implementation (Radiation Act, Section 139(3)).

During the fallout situation, priority decontamination measures shall be targeted to living environments where people spend most of their time or where there are many people. These typically include housing, work and service facilities, such as residential buildings, shopping centres, hospitals, health centres and sheltered housing units, schools, daycare centres and commercial, office and industrial buildings. Decontamination measures are primarily targeted at the indoor areas of such buildings. In industrial production facilities, all such structures and equipment must be cleaned from which radioactive material could be transported into the products. Also, the buildings' external surfaces and, for example, roads and yards must be cleaned.

Cleanliness of public spaces and buildings where children spend long periods of time or where many people visit, such as schools and daycare and shopping centres, should be verified after decontamination. Decontamination should be repeated if monitoring indicates an external dose rate in excess of 1 μSv/h.

Decontamination and ventilation of buildings' indoor areas are very important. Ventilation and decontamination are needed because some radioactive material from the passing plume will enter the buildings despite efforts to block the air intakes. Indoor areas where most time is spent should be cleaned particularly carefully. Cleaning must be carried out as quickly as possible after contamination to reduce the exposure time and allow for more effective removal of radioactive materials before they attach firmly to the surfaces. Some radioactive materials may need more than one cleaning. Radioactive materials may also be reintroduced indoors. Therefore, cleaning should be repeated.

Vehicles, tools and goods that have been outdoors must also be cleaned. Moving from a more contaminated area to a less contaminated or clean area is subject to adequate monitoring and decontamination measures. Therefore, any traffic from a more contaminated area must be directed to monitoring and decontamination points to measure the contamination level of people, vehicles, work machines, work equipment and goods. Human decontamination is discussed in chapter 3.1.10.

When cleaning the living environment, possible radiation exposure from the decontamination work must be considered. Protective clothing and respirators must be used, especially if the work is dusty. Radiation exposure must be considered in decontamination, both instructed by the authorities and self-cleaning.

Indoor areas

The radiation dose to people can be significantly reduced by simple indoor cleaning methods (vacuum cleaning, wet wiping of surfaces, washing). Decontamination of indoor areas should be done like an ordinary, thorough cleaning. Dust-generating work methods that remove and re-suspend radioactive material on the surfaces back into the air should be avoided. This would cause contamination of the skin, hair and clothing, increase exposure via inhalation and spread radioactive materials into already cleaned indoor areas. If the appropriate recommended indicative operational intervention levels are exceeded for a long time, decontamination of the indoor areas should be repeated regularly.

If the environment is heavily or extremely contaminated, it is necessary to carry out thorough decontamination of all indoor surfaces and furniture, including cleaning all surfaces and washing all household textiles and furniture.

Indoor decontamination should be started from the rooms where most time is spent. Other less frequented rooms, such as warehouses, cellars and attics, are cleaned after that.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR CLEANING INDOOR AREAS:

Cleaning indoor areas

– the external dose rate outdoors is or has been higher than 1 μSv/h,

or

– the deposition of strong gamma and beta emitters outdoors is or has been higher than 100,000 Bq/m^2,

or

– the deposition of alpha emitters outdoors is or has been higher than 1,000 Bq/m^2, provided that the emitters are in a form that allows their removal.

Thorough decontamination of all indoor surfaces

– the external dose rate outdoors is or has been higher than 10 μSv/h,

or

– the deposition of strong gamma and beta emitters outdoors is or has been higher than 1,000,000 Bq/m^2,

or

– the deposition of alpha emitters outdoors is or has been higher than 10,000 Bq/m^2, provided that the emitters are in a form that allows their removal.

Air filters in buildings should be replaced or cleaned as soon as possible after the plume containing radioactive materials has passed. This prevents radioactive materials attached to a filter from coming loose and entering indoor areas. Used filters and filter cleaning waste must be sealed in a bag or container and delivered as instructed to a separate waste collection point arranged for the purpose. The above also applies to vacuum cleaner dust bags. Other waste from cleaning can be disposed of with normal mixed waste.

INDICATIVE OPERATIONAL INTERVENTION LEVELS WHERE SEPARATE CLEANING OF INDOOR AREAS IS NOT REQUIRED:

– the external dose rate outdoors is less than 1 μSv/h,

or

– the deposition of strong gamma and beta emitters outdoors is less than 100,000 Bq/m^2,

or

– the deposition of alpha emitters outdoors is less than 1,000 Bq/m^2, provided the alpha emitters on the material surfaces may be in non-fixed form.

Built-environment outdoor areas

Decontamination measures in the built-environment outdoor areas aim to reduce the external radiation dose rate as quickly as possible to less than 10 μSv/h to avoid the need for long-term evacuation. It is, however, justified to carry out decontamination measures also below this value. In the long term, the objective is to reduce the external radiation dose rate below 1 μSv/h.

Urgent decontamination measures are required in the following areas:

- heavily or extremely contaminated areas where residents have not been evacuated
- areas where the public has been temporarily evacuated and areas which can be quickly restored for residential use by decontamination.

The protection of workers involved in the decontamination measures is discussed in chapter 3.1.9.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR URGENT BUILT-ENVIRONMENT DECONTAMINATION:

– the external radiation dose rate outdoors is higher than 10 μSv/h,
or
– the deposition of strong gamma and beta emitters is higher than 1,000,000 Bq/m^2,
or
– the deposition of alpha emitters is higher than 10,000 Bq/m^2, provided that the emitters are in a form that allows their removal.

Decontamination measures are started from people's immediate living environment, including the outer surfaces of residential buildings, schools, daycare centres, business premises, offices and production facilities and yards, parks, playgrounds, passageways and other areas that people have to use. Measures that can be easily and extensively implemented are carried out first. Likewise, decontamination measures, the effectiveness of which depend on how soon they are carried out after the fallout, are carried out as a matter of urgency. These include, for example, removing snow and collecting cut grass.

Decontaminated surfaces in built-up areas vary considerably in surface quality and the size of the surfaces. The surfaces can roughly be divided as follows:

- outer surfaces of buildings
- roads, streets and other covered areas, including asphalted, tiled, sand-covered and paved areas
- land areas and green spaces (lawns, sand surfaces, unmanaged urban areas)
- trees and bushes.

Annex 9 lists decontamination methods with factors influencing their choice and observations on their suitability, scheduling and the waste generated from their use. Annex 10 includes examples of other living environment-related measures to reduce human exposure from environmental contamination.

Natural environment

Decontaminating the natural environment is usually not appropriate. In this case, radiation exposure is reduced via restrictions of use in the area (see chapter 3.2.2).

Vehicles and machinery

Vehicles and machinery kept outdoors will be contaminated similar to the environment, so they must be washed before use.

Vehicles, machinery and tools used for handling contaminated materials in contaminated areas must be decontaminated regularly to reduce, first and foremost, the exposure of people inside or operating the vehicle, machine or tool. The activity is accumulated especially in the air filters and on the mudguards, chassis and tyres of vehicles and machinery driven in contaminated areas. Vehicles, machinery and tools are cleaned by washing with water.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR DECONTAMINATION OF VEHICLES AND MACHINERY:

– the external dose rate in the environment exceeds 10 µSv/h,

or

– the deposition of strong gamma and beta emitters in the environment exceeds 1,000,000 Bq/m^2,

or

– the deposition of alpha emitters in the environment exceeds 10,000 Bq/m^2, and the emitters are in a form that allows their removal.

Vehicles and machinery that come from a contaminated area to a clean area must be measured at a monitoring point established for that purpose and, if necessary, decontaminated. Usually, the available monitors are radiation survey meters that only measure external gamma dose rate. Decontamination is always required when a vehicle or machine has moved in an area with a high risk of contamination or if the monitor detects a higher reading than the prevailing radiation level in the area. In a clean area, for example, the order of magnitude for such an exceedance would be approximately 1 µSv/h. Measurements shall be made as close as possible to the monitored object without touching it.

If, despite the decontamination measures, the external dose rate due to radioactive material on the surfaces of a vehicle or machine exceeds the prevailing radiation level in the environment by more than 10 µSv/h measured inside the vehicle or machine, the vehicle or machine should be taken to a decontamination point for thorough cleaning. For example, if the external radiation dose rate inside a vehicle or machine is 10 µSv/h higher than in the environment, using it for 200 hours will result in an additional dose of 2 mSv for the occupants.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR RESTRICTING THE USE OF VEHICLES AND MACHINERY:

The use of a vehicle or machinery should be limited to temporary and short transport or operations if

– the external radiation dose rate measured inside the vehicle or machinery after thorough decontamination is still more than 10 μSv/h above the prevailing radiation level in the area.

A vehicle or machinery **must not be used** if

– the external radiation dose rate measured inside the vehicle or machine after thorough cleaning is still more than 100 μSv/h above the prevailing radiation level in the area.

Tools, goods and raw materials

Tools and goods kept outdoors will be contaminated similar to the environment, so they must be washed before use.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR CLEANING TOOLS:

– the external radiation dose rate in the environment exceeds 10 μSv/h,

or

– the deposition of strong gamma and beta emitters in the environment exceeds 1,000,000 Bq/m^2,

or

– the deposition of alpha emitters in the environment exceeds 10,000 Bq/m^2, and the emitters are in a form that allows their removal.

Tools used for the handling of contaminated materials must be cleaned regularly to reduce, first and foremost, the exposure of people using the tools.

The aim is to avoid bringing items from heavily contaminated areas to less contaminated or clean areas before first verifying their contamination level. Items should not be brought from an extremely contaminated area until they can be measured at a monitoring checkpoint established for that purpose.

Items that have been outdoors, or in some cases even indoors without protection, may be surface contaminated. The items must be cleaned or, if packed, the outer packaging must be removed. When removing the packaging layer, care must be taken not to contaminate the item. The packaging layer is handled and disposed of as described in chapter 4 (waste containing radioactive material). In case decontamination of the item is not possible or the external dose rate caused by the item exceeds 1 μSv/h after cleaning, the item should be protected with plastic, if possible, and its usability assessed separately on a case-by-case basis. Plastic is used to prevent the spreading of contamination from the items when moving them.

If the external dose rate on the surface of an item exceeds 100 μSv/h, the item should be stored temporarily in a place where it does not cause additional exposure to workers or other people.

Decontamination points

Decontamination points for the cleaning of vehicles, machinery, tools and goods must be established near the border between a contaminated and clean area. Where necessary, decontamination points for machinery and vehicles should also be established in the contaminated area to reduce contamination of work equipment, machines, etc., during operation. Decontamination points must be located in places with sufficient water supply for washing and where the washing water can be discharged to the sewer network. Separate collection tanks for the washing water are not usually required.

Decontamination points become contaminated, accumulating activity in, for example, septic tanks and wastewater pumping stations. Therefore, the washing points must be cleaned at regular intervals. People who carry out decontamination work on a regular basis must protect themselves by wearing protective clothing and respirators that can be decontaminated. Protective clothing shall be washed and replaced with clean clothing at regular intervals.

The decontamination points shall have a collection point for contaminated packaging material.

Monitoring and decontamination points shall also be arranged at suitable locations for rail and waterborne traffic, airports and border crossing points.

3.2.2 Restrictions on the use of land and water areas

In a nuclear or radiological emergency, the aim is to clean the living environment so that there is no need to restrict its use. However, restrictions on the use of a contaminated built or natural environment may be necessary if decontamination is not possible or appropriate. The use restrictions on land and water areas concern activities that are not absolutely necessary, such as leisure time activities, prolonged stay and other recreational use.

The timing or duration of the restrictions may vary. Area use restrictions may have been required already in the early phase. The restrictions shall be further specified as more detailed information on the fallout situation becomes available. Some restrictions may last for several months or years. Besides radiation protection aspects, social, environmental, economic and other factors must also be considered when deciding on long-term restrictions. Restrictions on the use of land areas may also concern their future use for, for example, residential or agricultural purposes. Restrictions on the future use of an area in the recovery phase are not discussed in this guide.

Restrictions can be lifted or relaxed when a better understanding of the fallout area and radiation levels there has been obtained, and the exposure from the deposition found sufficiently low. Factors reducing the exposure from the deposition include

- decomposition of short-lived radioactive material
- natural decontamination of surfaces; for example, rain and wind remove radioactive material from different surfaces
- adhesion of radioactive material to surfaces or penetration into deeper soil layers; this also reduces the risk of spread of radioactive material
- cleaning the areas.

Restrictions on recreational use in an area must consider both the risk of contamination and external radiation. Here, the risk of contamination refers to the contamination of the skin, hair and clothes with radioactive material and the migration of radioactive material to, for example, indoor or clean areas. When taking pets outside, it must be remembered that they bring radioactive material indoors on their fur and feet. Therefore, the place should be chosen such as to minimise their contamination. Pets should be washed when entering indoors.

During the first few months, it may be necessary to restrict movement in an area due to the risk of contamination, even if the external radiation dose rate does not require it. The risk of contamination decreases relatively rapidly. Restrictions on the use of areas due to the risk of contamination are likely required for a maximum period of one year.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR RESTRICTING THE USE OF BUILT RECREATIONAL FACILITIES (E.G. PARKS, PLAYGROUNDS):

– the external radiation dose rate exceeds 1 μSv/h,
or
– the total deposition of strong gamma and beta emitters exceeds 100,000 Bq/m^2,
or
– the deposition of alpha emitters exceeds 1,000 Bq/m^2, and the emitters on the material surfaces may be in non-fixed form.

Possible restrictions on recreational activities in an area include

- restricting people from moving and exercising outdoors, for example, in nature and recreational areas
- restricting the use of parks and other built recreational facilities, such as playgrounds
- restricting fishing, hunting and harvesting of natural products
- restricting the use of contaminated shore areas, such as swimming beaches.

In most fallout situations, restrictions concerning access to playgrounds, parks, public events (e.g. outdoor concerts, outdoor fairs, sports competitions) and recreational areas (e.g. amusement parks, camping sites, golf courses, ski resorts, nature trails) can be relaxed or lifted after a few months.

INDICATIVE OPERATIONAL INTERVENTION LEVELS FOR RESTRICTING THE RECREATIONAL USE OF NATURAL AREAS (E.G. FORESTS):

– the external radiation dose rate exceeds 10 μSv/h,
or
– the total deposition of strong gamma and beta emitters exceeds 1,000,000 Bq/m^2,
or
– the deposition of alpha emitters exceeds 10,000 Bq/m^2, and the emitters on the material surfaces may be in non-fixed form.

The activity concentration limits applied to game, fish, berries and mushrooms and other harvested natural products shall be the same as those regarding the use of other foodstuffs (see chapter 3.3). However, even if fishing and mushroom picking should be restricted for a longer period because of elevated activity concentrations, the restrictions on moving in the area can be lifted at an earlier stage.
In water areas, radioactive material is diluted in large quantities of water. Even if fishing is restricted, it does not prevent other recreational activities, such as boating or swimming.

Spending time at the shore, however, may have to be restricted due to contamination of the shore soil.

3.2.3 Business activities in a contaminated area

Contamination of the living environment may affect business activities and give rise to specific measures. Such measures may include, for example, the reorientation or, in extreme cases, the limitation of production activities. Contamination of the living environment may affect

- production, including industry, agriculture and forestry, peat and biofuel production and professional fishing
- other business activities, including central warehouses and service activities related to tourism and recreation.

When considering the continuation of business activities, the exposure to workers, contamination of the produced goods or raw materials and possible exposure to customers must be taken into account. Worker exposure is discussed in chapter 3.1.9. Tourism and leisure-related service activities are subject to the criteria for the recreational use of land and water areas (chapter 3.2.2). Measures concerning agriculture and food production are discussed in chapter 3.3.

The acceptability of the use of raw material and products necessary for business activities shall be assessed separately, considering the activity concentration of the raw material, the migration and interaction of radioactive material in the production process and the intended use of the finished product. During a nuclear or radiological emergency, concentration or contamination limits should be considered for each product according to its end-use. If these limits cannot be achieved, raw material could be acquired from clean areas or the production reorientated to produce less contaminated products or products for other purposes. The Radiation and Nuclear Safety Authority provides case-specific instructions on the acceptability of the use of products. The aim is to ensure that the annual dose from continuous use of the products does not exceed 1 mSv.

Even if the exposure is low, authorities in other countries may impose more stringent purity criteria on goods imported from Finland than the Radiation and Nuclear Safety Authority's indicative limits. Authorities in other countries may also impose separate contamination criteria for the vehicles used to transport the goods.

There are case-specific methods to reduce the migration of radioactive material from the ecosystem to the final products. In forestry, for example, fertilising decreases the uptake of radioactive material by the roots of plants and trees. Forest harvesting should be planned in the long term so that trees ready for harvesting are felled before their gradual contamination. The use of raw material can be orientated, for example, to the production of paper (instead of mechanical wood processing, such as furniture and house production) where only a part of the radioactive material ends up in the final product.

3.3 Measures concerning foodstuffs, household water and animal feed

In case of a nuclear or radiological emergency, foodstuffs, their raw material and animal feed may become contaminated. Contamination can also occur at different stages of production and processing, for example, in the fields, greenhouses, warehouses, production facilities or shops. Subsequently, radioactive material may be transferred via the food chain into foodstuffs and humans.

Though the surface water may become contaminated in fallout situations, the groundwater remains clear because the migration from surface water to groundwater is very slow, and the soil layers act as a filter. The purity of tap water is ensured during water treatment. The quality of household water is verified by monitoring. Any restrictions on the use of household water consumption are likely to be short-term and concern the use of the water for drinking and cooking. Water contaminated with radioactive material can be used as washing water.

Activity concentration limits set for foodstuffs and animal feed within the European Union prevent the sale of said products if the limits are exceeded. Annex 11 presents measures for food and animal feed production and water supply that can reduce the quantities of radioactive material in products in case of a nuclear or radiological emergency. The selection, implementation and timing of the measures shall also consider factors other than the reduction of exposure from foodstuffs and water (see chapter 1.5).

Exposure from foodstuffs may need to be reduced by imposing more stringent sale and use restrictions than required by the maximum activity concentration limits for foodstuffs. This becomes necessary if the total dose from other exposure pathways cannot be reduced to an acceptable level by other measures, such as environmental decontamination.

The quantities of radioactive material in foodstuffs and animal feed must be ascertained before placing the products on the market. The quantities of radioactive material can be measured or estimated based on the fallout situation in the area and considering the transfer of radioactive material in foodstuffs and animal feed. Monitoring and assessing are mutually complementary measures, but the reliability of the assessments must be verified by measurements. Products exceeding the limit values or not acceptable because of the radioactive material in them must be treated as waste (see chapter 4) unless they can be otherwise utilised.

3.3.1 Activity concentration limits for foodstuffs, household water and animal feed

Concentration limits for foodstuffs and household water within the EU

Enforcing the concentration limits

A fallout situation may require restrictions concerning the use of foodstuffs. The EU Commission has the power to impose the implementation of pre-established concentration limits for radioactive material in foodstuffs, and the member states are obliged to act accordingly. The concentration limits are applied in intra-EU trade, and foodstuffs that exceed the limits may not be exported. Unless specifically provided otherwise, the limits also apply to the import of foodstuffs into the EU. The concentration limits are provided in Table IV.

If the situation so requires, concentration limits falling within the EU's competence may be amended and their term of validity adjusted by an EU Council decision. In a situation lasting for several years, the concentration limits can be tightened where possible and reasonable. Raising the concentration limits may be necessary in case of an additional wide-ranging crisis situation affecting the food supply during a nuclear or radiological emergency. Concentration limits may also be raised in the case of an individual, infrequently used foodstuffs.

If the European Union has not imposed restrictions on the placing on the market of foodstuffs, such restrictions may be decided upon at the national level. In this case, food security, access to clean foodstuffs and the social and economic factors related to food production, for example, must be taken into account. Then, concentration limits corresponding to the EU concentration limits can be introduced at the national level even if the Commission has not imposed them.

Concentration limits for foodstuffs and household water

Table IV includes the activity concentration limits for foodstuffs sold in the EU. Concentration limits for liquid foodstuffs may also be applied to household water, although this is not required by EU legislation.

TABLE IV. Concentration limits for foodstuffs[5].

	Activity concentration, Bq/kg		
Radionuclides [a]	**Baby food**	**Dairy products and liquid foodstuffs**	**Other foodstuffs [b]**
Strontium isotopes in total	75	125	750
Iodine isotopes in total	150	500	2,000
Plutonium and transplutonium isotopes in total	1	20	80
Other radionuclides in total [c], with half-life over 10 days, e.g. caesium-134 and caesium-137	400	1,000	1,250

a Activity concentrations determined for the different radionuclide groups are not dependent on each other; each shall be applied separately.
b For some not frequently used foodstuffs, e.g. certain spices, the concentration values to be enacted are ten times higher than those for basic foodstuffs in this table.
c Excluding carbon-14, potassium-40 and tritium.

5 Council Regulation (Euratom) 2016/52, Council Regulation (EEC) No 2219/89

As a result of the Chernobyl accident, separate concentration limits have been set for foodstuffs imported to the EU from non-EU countries. These limits also apply to natural products sold in Finland. Since the Fukushima accident, specific concentration limits have been set for food imports from Japan. Concentration limits for foodstuffs imported from non-EU countries are provided in Annex 13.

International trade in foodstuffs with non-EU countries

The international trade in foodstuffs follows the recommended concentration limit values provided in Table V of the Codex Alimentarius (CODEX STAN 193-1995, amended 2018) by FAO and WHO unless otherwise required by national legislation or common EU food law. The limits apply to both export and import trade. Export of foodstuffs shall comply with the regulations of the country of destination.

The aim of the Codex Alimentarius is to keep the total exposure from foodstuffs in the first year following a nuclear or radiological emergency below 1 mSv. This is achieved if the proportion of contaminated foodstuffs approaching the concentration limits is 10%, and that of non- or almost non-contaminated foodstuffs is 90% of the total consumption during the first year. Therefore, the individual concentration limits in Table V do not guarantee that the total exposure from foodstuffs will remain below 1 mSv. Annex 12 contains a table of the average annual food consumption in Finland.

If the conditions are so severe that the dose of 1 mSv is exceeded, the aim shall be to keep the exposure below 10 mSv also in the first year.

The Codex Alimentarius limits will not be lowered in later years either because it is expected that the number of contaminated products in international trade will decrease due to, for example, the market mechanism and measures to decrease the concentrations in foodstuffs. It is likely that the proportion of contaminated foodstuffs will remain well below one per cent of the total consumption.

Individual countries may consider deviating from the Codex Alimentarius limits at a national level if their proportional consumption of contaminated foodstuffs approaching the concentration limits exceeds 10%. Such a situation may occur following a very extensive fallout, for example. Individual countries may also consider a lower limit in the case of high-consumption foodstuffs, such as milk.

TABLE V.

Codex Alimentarius[6] guideline levels for trade in foodstuffs with non-EU countries.

Radionuclides	Activity concentration, Bq/kg	
	Baby food	Other foodstuffs
Plutonium-238, plutonium-239, plutonium-240 and americium-241 in total	1	10
Strontium-90, ruthenium-106, iodine-129, iodine-131 and uranium-235 in total	100	100
Sulphur-35, cobalt-60, strontium-89, ruthenium-103, caesium-134, caesium-137, cerium-144 and iridium-192 in total	1,000	1,000
Tritium, carbon-14 and technetium-99 in total	1,000	10,000

Concentration limits for animal feed within the EU

Table VI contains the concentration limits for animal feed to be complied with within the EU by a Commission decision. Compliance with the animal feed concentration limits does not guarantee that the activity concentrations in the foodstuffs produced will remain below the relevant limits. If there is not enough animal feed below the concentration limits available, animal feed exceeding the limits may be used to supplement the feeding to safeguard the well-being of the animal.

Concentration limits are applied both in intra-EU trade and imports into the EU. The member states are obliged to comply with the concentration limits. Animal feed exceeding the concentration limits may not be exported. In Finland, the same concentration limits are also used in situations where the Commission has not yet imposed the implementation of the concentration limits.

TABLE VI. Concentration limits for animal feed (caesium-134 and caesium-137[7])

Animal group	Activity concentration in feed, Bq/kg*
Pigs	1,250
Poultry, lambs and calves	2,500
Other	5,000

* The aim of the values is to affect the food chain to ensure the observance of the maximum foodstuffs activity concentration limits. However, the values alone cannot guarantee such observance in all situations, and they do not remove the requirement for monitoring the activity concentrations in animal products intended for human consumption. These values apply to animal feed as ready for consumption.

6 General Standard for Contaminants and Toxins in Food and Feed CXS 193-1995

7 Council Regulation (Euratom) 2016/52

3.3.2 Measures concerning food and feed production, further processing and water supply

The measures concerning food and feed production, water supply and further processing aim to keep the concentrations of radioactive material in foodstuffs and water for human consumption below the concentration limits given in chapter 3.3.1. Products that have been well protected in the early phase, such as raw materials and feed, will remain clean.

Contamination of production facilities may also contaminate the end products or raw materials. Therefore, production facilities must be carefully decontaminated even in areas with relatively low fallout. In the longer term, the main cause of contamination of the end product in food production and further processing is raw materials. Raw materials can be sourced from a clean area, or a clean substitute raw material may be used, for example. In the case of further processing, the possibilities for reducing the quantities of radioactive material contained in the end products are limited. Furthermore, there is no guarantee that consumers will accept the products for use. Annex 11 presents various measures concerning primary production, further processing and water supply.

3.3.3 Measures concerning the use of natural products and cultivation for own consumption

The Radiation and Nuclear Safety Authority and food safety authorities provide guidance and recommendations to households on the use of natural products and cultivation for their own consumption. It may include advise about the possibilities of having foodstuffs measured or, for example, recommendations to avoid such species of plants, fish, game or mushrooms that accumulate significantly more radioactive material. The aim is to keep exposure due to foodstuffs from natural products and self-cultivated crops as low as possible.

4. Waste containing radioactive material

4.1 Waste sorting and disposal solutions

Waste that contains radioactive material may be generated in decontamination or from discarded products. These wastes cannot necessarily be processed via the normal waste management because of the following:

- The amount of waste produced, especially resulting from decontamination and restrictions of use of foodstuffs, may be extremely high;
- The waste may be abnormal or unsuitable for the normal waste management (e.g. disposal of milk);
- The radionuclide inventory exceeds the limit for disposal via normal waste management routes.

Waste containing radioactive material should be sorted according to the amount of radioactive material and type of waste. Wastes of different type and different activity levels should be kept apart to the extent possible so they can more easily be utilised in various practical applications or disposed safely. Where contaminated goods, structures, devices, materials or material are concerned, the contaminated parts of goods are separated from the clean parts as far as possible. For the purposes of waste management, it is better that a small amount of moderately active waste is generated than a large amount of low active waste.

Collection points for goods and packaging that may have been contaminated must be arranged in areas where such waste can be generated.

All facilities used for the temporary storage of contaminated waste must be of such design that they can be isolated from third parties. The temporary storage facilities must be isolated from third parties in such a way that the dose rate outside the isolated area does not exceed 10μSv/h. Temporary storage is more concerted and long-term activity than early-phase isolation, meaning that stricter isolation area criteria apply.

Types of waste containing radioactive material include the following:

- solid materials, such as collected dust from streets or from decontamination, incineration ash, waste from demolished buildings, soil, goods, devices;
- liquids;
- sewage sludge from wastewater and raw water treatment;
- sewage from stormwater inlets;
- snow, such as surface snow removed from yards;
- biomasses, such as growth, feed, peat;
- discarded foodstuffs and feed.

If the amount of waste is large, the waste should be processed to reduce the amount or to convert it into a more suitable form in order to dispose of it. Possible ways of processing include the following:

- composting, digestion or incineration of the biomass in appropriate facilities;
- filtering liquids, or decontaminating them in some other manner;
- solidifying liquids;
- chemically treating liquids.

It should be noted that by composting, the radioactive material is concentrated so effectively that the end product must not be used for cultivating foodstuffs. Furthermore, such large amounts of radioactive material may concentrate in waste incineration ash that this can affect the processing of that material.

Disposal of waste containing radioactive material is to be based on some of the following main principles:

Aging
If the waste contains only short-lived radioactive nuclides, temporary storage of the waste is often the best solution. Aging is a method whereby wastes are stored temporarily until their radioactivity has reduced such that they can be processed.

Encapsulation
Encapsulation means that waste is located remotely from the living environment. Waste that must be placed in a specific radioactive waste disposal facility is generated only in very extraordinary incidents, such as in accidents involving a radiation source. Usually, waste is disposed of at a dumping area or a separate covered soil dumping site. Some waste can be used in earthworks.

Dilution

Dilution is usually not acceptable, but it may in certain cases be the best solution as a whole. For example, it might be appropriate to dump a large amount of mildly contaminated snow into the sea: the radioactive material will then be diluted into such a large volume that it has no significance from a radiation protection point of view. Alternatively, if snow is dumped on solid ground, the melting of the snow may concentrate the radioactive material on the soil, or melt waters may transport some or all of the radionuclide inventory into the environment.

4.2 Classification of waste containing radioactive material by activity concentration

Various types of radioactive waste of differing activity levels are generated as a result of decontamination measures taken in radiological emergencies as well as from discarded products. Radioactive waste can be divided roughly into four waste management categories according to the activity concentration (Table VII):

Category I: waste requiring isolation from the living environment;

Category II: waste requiring controlled waste management to limit radiation exposure;

Category III: waste requiring assessment of possible radiation exposure;

Category IV: waste requiring no controlled waste management to limit radiation exposure but not suitable for the intended use on account of low-level contamination.

Category I waste is radioactive waste pursuant to the Radiation Act. Categories II–IV are not actual radioactive waste, and the processing of this waste is governed by the Waste Act. Account must nevertheless be taken of the radiation protection of workers whenever processing any such waste.

All decontamination measures must be implemented in a systematic manner. The amount and quality of the waste generated from decontamination measures must be assessed before taking any such measures.

TABLE VII. Activity concentrations of the waste categories. Applies to large volumes of over 100m^3, stricter limit values can be applied to smaller volumes.

Waste category	Activity concentration (Bq/kg)		
	Alpha emitters	Strong gamma and beta emitters	Weak gamma and beta emitters
I	over 100,000	over 1,000,000	over 10,000,000
II	1,000–100,000	10,000–1,000,000	100,000–10,000,000
III	100–1,000	1,000–10,000	10,000–100,000
IV	below 100	below 1,000	below 10,000

4.3 Management of waste and possible recycling

Category I.
Waste requiring isolation from the living environment
Category I waste is radioactive waste within the meaning of the Radiation Act. Wastes in Category I contain such large amounts of radioactive material that they must be encapsulated from the living environment on the grounds of radiation protection. Waste in this category cannot be used or processed in the normal waste management as the radiation effects would not remain acceptably low. The waste must either be temporarily stored for an indefinite period (especially in case of short-lived radionuclides) or encapsulated permanently from the living environment (especially in case of long-lived radionuclides).

The workers involved in waste management activities may be exposed to a significant radiation dose. Therefore it is absolutely necessary to assess the workers' exposure when planning and executing the waste management tasks. Where any strong gamma emitter such as caesium-137 is concerned, the dose to a worker who continuously processes such waste may be more than 6 mSv per month.

In an extensive fallout situation, Category I waste may occur at the scene of the accident and in the immediate vicinity. Category I waste may also occur at a long distance, when waste containing a smaller amount of radioactive material is processed in such a manner that the radioactive materials concentrate into a smaller volume or mass (for example, incineration ash in some cases, composted biomass). Air filters in use during the passing of a radioactive plume may also accumulate significant amounts of radioactive material. Additionally, the material accumulated from mechanical brush cleaning of streets may, in terms of its activity, be classified under this category. If rainwater in buildings is led directly to topsoil, the discharge spot in the soil may hold large amounts of radioactive material. The volume of Category I waste that occurs can vary greatly depending on the waste management solutions employed in any given situation.

In an emergency involving a radiation source, Category I waste may occur right at the accident site. Usually, waste volumes at individual sites are small, not more than a few cubic metres.

Category II.
Waste requiring controlled waste management to limit radiation exposure
With regard to Category II waste, it may be difficult to find a utilitarian purpose where the radiation impacts of the waste would remain acceptably low. This is why the waste must either be stored temporarily (especially in case of short-lived radionuclides) or encapsulated permanently by employing a suitable measure (especially in case of long-lived radionuclides). The number of possible actions may however be a lot more variable than in the case of waste in Category I.

Workers involved in waste management activities may be exposed to a significant radiation dose. Workers' exposure must therefore be monitored and, where necessary, exposure should be assessed and optimized when planning and executing the waste management tasks. Where any strong gamma emitter such as caesium-137 is concerned, the dose to a worker who continuously processes such waste may be more than 1 mSv per month.

Category II waste includes: removed topsoil and snow, dust bags of vacuum cleaners and other cleaning utensils, ash from incineration of peat and other bio fuels. The amount of waste in this category may be great, even hundreds/tens of thousands of cubic metres.

Category III.
Waste requiring assessment of possible radiation exposure
Category III wastes are wastes whose recycling, management and final disposal solutions are mainly based on their normal use but where the solutions selected to manage them must take account of various radiation safety aspects. In choices of waste disposal, such solutions must be looked for where needs for processing and later storing of large masses would remain as low as possible.

Category III waste can be used for constructing roads, streets and similar, and also for landscaping when otherwise suited for this kind of use. In this case it should be ensured that a thick enough layer of clean material is placed over the decontamination products. In case of constructing, for example, a road, it is enough if the covering layer consists of 10–20 cm of rock material. Decontamination products should not, however, be left in the immediate vicinity of residences.

When choosing the disposal site, the future use of the area must be taken into account. If the disposal site is intended to be used for the primary production of foodstuffs, such a thick layer of clean material is needed that ploughing and roots of plants do not reach the waste layer.

The radiation exposure of workers participating in the processing of Category III waste remains minor. Doses to workers involved in the management of such waste are unlikely to exceed 1 mSv per year.

Category III waste includes: topsoil and plants removed in decontamination of the living environment, food and feeds exceeding the permitted maximum levels, as well as contaminated goods, materials and structures that cannot be decontaminated to meet the release criteria. The amount of waste in this category may be very high, millions of cubic metres or more.

In waste management, the concentration of radioactive material must be taken into account. As a result of composting or other similar process, the activity level of waste may increase to levels thereby moving the waste into Category II.

Category IV.
Waste requiring no controlled waste management to limit radiation exposure but not otherwise suitable for the intended use on account of low-level contamination
Radiation protection requirements do not limit the normal disposal of this waste. Workers are not exposed to radiation. The amount of waste in this category may be very high.

Category IV waste includes: food and raw materials that are below the permitted maximum levels, and also other goods and products below the limit values which are not acceptable to their intended use due to radioactive contamination.

Annexes

Annex I: Estimated consequences of radiological emergencies

The consequences of an accident causing a radiological emergency can affect a wide area only if significant amounts of radioactive material are released into the air. In this case, the material travels by means of air currents as an invisible plume that contains radioactive material. The wind speed determines the speed at which the plume moves, while the direction determines the area contaminated. As the plume makes its way, it expands and becomes diluted, its radioactivity reducing.

In the plume's path, radioactive material is deposited on the ground and on all surfaces. Depositions can have local differences that may be great. Rain, for example, may increase the number of particles depositing in the environment.

Waterways can carry aquatic releases over a wide area. These do not pose any radiation hazard to people, but increased levels of radioactive material are observable in the fish in the area.

The table shows some examples of various radiological emergencies and how wide-ranging effects they could at worst have. Additionally, the table contains estimates of the geographical extent of the area where protective actions would be necessary in a worst-case scenario. The consequences of emergencies may vary greatly depending on what and how much radioactive material is released.

Examples of consequences of radiological emergencies		
Geographical extent of consequences	**Cause of radiological emergency**	**Maximum distance from point of dispersion calling for radiological protective actions**
Widespread fallout	nuclear weapon explosion	from a few kilometres to thousands of kilometres; depends on the size of the nuclear weapon, explosion height and prevailing weather conditions
	severe accident at nuclear power plant	evacuation from a few kilometres up to 20 km; sheltering indoors up to 100 kilometres; avoidance of unnecessary stay outdoors up to 200 km, measures concerning protection of livestock production may be needed in the range of a thousand kilometres
	crash of nuclear-powered satellite	crash area of parts that may have spread over an area of hundreds of square kilometres; individual parts that can be extremely active may land in any parts of the area
Regionally limited fallout	spent nuclear fuel storage accident	up to tens of kilometres
	severe reactor accident on a nuclear vessel	up to tens of kilometres
	accident in storage, handling or transportation of nuclear weapons; nuclear weapon material is evaporated into air	up to tens of kilometres
	spreading radioactive material by an explosive, i.e. a dirty bomb or other deliberate contamination of a limited region with radioactive material	up to a few kilometres
Contamination of indoor areas or immediate vicinity of the accident site	accident in transfer or transport of spent nuclear fuel	up to hundreds of meters
	release of radioactive material during transport	up to hundreds of meters
	accident (fire, chemical explosion) at the site of radioactive material	up to hundreds of meters
	high-activity radiation source ending up in metal melting	factory area and immediate vicinity
	unshielded high activity source	under one hundred metres
	accident in use of radioactive material	indoor areas at the site
	intentional contamination of indoor areas with radioactive material	the indoor areas concerned

ANNEX 2: Operational intervention levels for protective actions in early and intermediate phase of radiological emergency

Indicative operational intervention levels for protective actions in early phase of radiological emergency

This table lays out the indicative operational intervention levels (OILs) in the early phase of a radiological emergency that are presented in the guide. It must be pursued to take the necessary protective actions in the early phase of a radiological emergency before the radiation level in the area increases. Consideration should be given to carrying out the protective actions at the latest if the OIL and the dose criteria are estimated to be exceeded. OILs are given as an external dose rate, expressed as microsievert per hour (μSv/h = microsievert/h).

There are radioactive materials that do not cause the external dose rate to increase to a high level but that, when introduced into the human body, can cause significant exposure (for example, alpha emitters). If such materials are released into the environment, protective actions may be necessary even where the dose rate remains below the OILs shown in the table.

Protective measure necessary when radiation level exceeds	Protective measure
100 μSv/h	• Sheltering indoors • Iodine prophylaxis: up to the age of 40 and pregnant women over the age of 40 • Access control • Protection of indoor areas against contamination
10 μSv/h	• Partial sheltering indoors • Iodine prophylaxis: children under 18 years old and pregnant women • Protection of production, trade, logistics and domestic water • Protection of workers engaged in emergency management • Temporary banning of sales and use of foodstuffs, feeds and natural goods until proven safe by means of measurements
1 μSv/h	• Protection of primary production of foodstuffs and feeds

Indicative operational intervention levels for protective actions in intermediate phase of radiological emergency

This table lays out the indicative operational intervention levels in the intermediate phase of a radiological emergency that are presented in the guide. Consideration should be given to carrying out the protective actions at the latest if the operational intervention level and the dose criteria are estimated to be exceeded. OILs are given as an external dose rate, expressed as microsievert per hour (μSv/h = microsievert/h) and as the extent of the deposition in the affected area.

There are radioactive materials that do not cause the external dose rate to increase to a high level but that, when introduced into the human body, can cause significant exposure (for example, alpha emitters). If such materials are released into the environment, protective actions may be necessary even where the dose rate remains below the OILs shown in the table.

Protective measure necessary when radiation level caused by deposition exceeds	Deposition a) strong gamma and beta emitters, total b) alpha emitters, assuming they are detachable from surfaces	Protective measure
100 μSv/h	a) greater than 10,000,000 Bq/m^2, or b) greater than 100,000 Bq/m^2	• Sheltering indoors, total duration less than two days • Access control
100 μSv/h in more than two days	a) greater than 10,000,000 Bq/m^2, or b) greater than 100,000 Bq/m^2	• Evacuation, duration from one week to a number of months • Where more than 10 μSv/h despite effective decontamination of the area, temporary relocation of the population lasting from a number of months to approximately two years
10 μSv/h	a) 1,000,000–10,000,000 Bq/m^2, or b) 10,000–100,000 Bq/m^2	• Partial sheltering indoors • Thorough decontamination of all indoor surfaces • Urgent decontamination of the built-up environment • Decontamination of vehicles, work machinery and tools • Restricting the recreational use of the natural environment • Protection of workers engaged in emergency management, such as in decontamination measures
1 μSv/h	a) 100,000–1,000,000 Bq/m^2, or b) 1,000–10,000 Bq/m^2	• Decontamination of indoor spaces • Restricting the use of built-up recreational areas, such as playgrounds

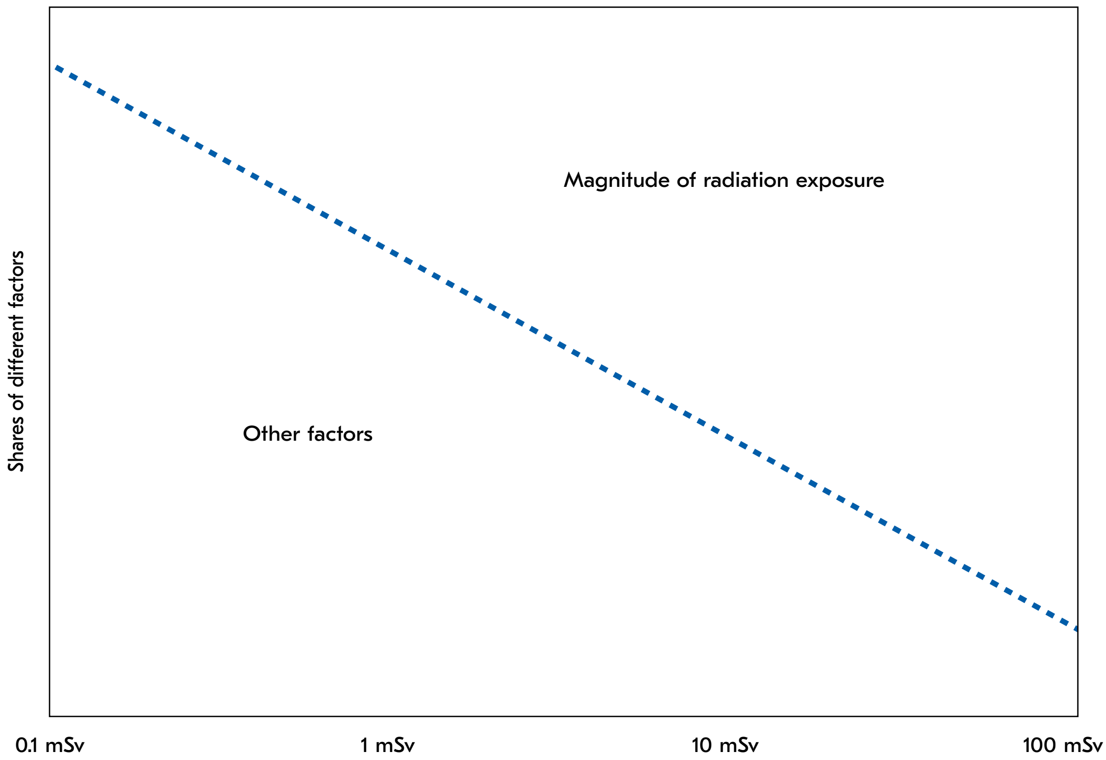


FIGURE 2-1. Balance of factors when deciding on protective actions (see 1.5).

ANNEX 3: Calculation examples for determining operational intervention levels

The operational intervention levels (OILs) are derived starting from the dose criteria defined for the measures. Taking into account the various types of uncertainties present during a genuine radiological emergency, in particular, in the radiological situation and in the development of such situation at a certain location, and because they do not necessarily include all exposure routes, the OILs are expressed as orders of magnitude. The tables below employ the dose coefficients for workers whenever these coefficients have not been specifically defined for the population.

The OILs for alpha, beta and gamma emitters are calculated for nuclides Pu-239, Sr-90 and Cs-137. Taking into account the materials most likely to be released in accidents, the levels of hazard they pose and the uncertainties concerning the exact composition of any possible release, these nuclides are also well representative of other possible materials where decision-making in a radiological emergency is concerned.

External dose rate	**Dose criteria: projected dose of 10 mSv in two days**
As there may be uncertainties and other possible exposure routes, the calculated value is rounded down to the nearest whole number.	**OIL** Dose rate = 10,000 μSv/h/ (2 x 24h) = 208 μSv/h **> 100 μSv/h**

Concentration in air (internal dose via inhalation)	**Dose criteria: projected dose of 10 mSv in two days**	
Inhalation rate 1 m^3/h As there may be uncertainties and other possible exposure routes, the calculated value is rounded down to the nearest whole number.	**Alpha** Committed dose for workers via inhalation (BSS 96/29/Euratom) Pu-239: 4.710^{-5} Sv/Bq	**OIL** Concentration in air = (0.01 Sv/ (2 x 24h)) / (4.710^{-5} Sv/Bq x 1 m^3/h) = 4.4 Bq/m^3 **> 1 Bq/m^3**
	Beta Committed dose for workers via inhalation (BSS 96/29/Euratom) Sr-90: 1.510^{-7} Sv/Bq	**OIL** Concentration in air = (0.01 Sv/ (2 x 24h)) / (1.510^{-7} Sv/Bq x 1 m^3/h) = 1,400 Bq/m^3 **> 1,000 Bq/m^3**
	Gamma Committed dose for workers via inhalation (BSS 96/29/Euratom) Cs-137: 6.710^{-9} Sv/Bq	**OIL** Concentration in air = (0.01 Sv/ (2 x 24h)) / (6.710^{-9} Sv/Bq x 1 m^3/h) = 31,100 Bq/m^3 **> 10,000 Bq/m^3**

Deposition	Dose criteria: projected dose of 10 mSv in two days	
In case of strong beta and gamma emitters, the most significant exposure route is direct radiation in the deposition.	**Strong gamma and beta emitters** Dose rate from deposition on surfaces: Cs-137: $2.5 \cdot 10^{-12}$ (Sv/h)/(Bq/m^2)	**OIL** Deposition on surfaces = (0.01 Sv/(2x24h)) / ($2.5 \cdot 10^{-12}$ (Sv/h) /(Bq/m^2)) = 80,000,000 Bq/m^2 > **10,000,000 Bq/m^2**
In case of alpha emitters, the most significant exposure route is the inhalation of re-suspension. As there may be uncertainties and other possible exposure routes, the calculated value is rounded down to the nearest whole number.	**Alpha, deposition detachable from surfaces** Committed dose for workers via inhalation (BSS 96/29/Euratom) Pu-239: $4.7 \cdot 10^{-5}$ Sv/Bq The re-suspension factor varies significantly depending on circumstances. On average, a re-suspension factor (RF) value of $1.2 \cdot 10^{-6}$ m^{-1} is employed for any detachable deposition. However, RF can be a factor of 10 higher, in particular in densely built-up areas with high volumes of traffic. That is why the calculation employs the following value: RF = $6 \cdot 10^{-6}$ m^{-1}.	**OIL** Concentration in air = (0.01 Sv/(2x24h)) / (4.7^{10-5} Sv/Bq x 1 m^3/h) = 4.4 Bq/m^3 Deposition = concentration in air / $6 \cdot 10^{-6}$ m^{-1} 4.4 Bq/m^3 / $6 \cdot 10^{-6}$ m^{-1} = $7.4 \cdot 10^5$ Bq/m^2 > **100,000 Bq/m^2**

ANNEX 4:
Key responsibilities concerning protective actions in radiological emergency

TABLE 4-I. Key responsibilities concerning protective actions in radiological emergency; source: Guideline for radiological situations (Publications by the Ministry of the Interior 10/2016).

Expert	Area of responsibility
Radiation and Nuclear Safety Authority	• assessing the safety significance of the situation • recommendations for protective actions to the public authority with decision-making power in the relevant administration
Finnish Meteorological Institute	• meteorological observations, forecasts and warnings • dispersion forecasts to STUK

Decision-maker	Area of responsibility
Director of rescue operations	• evacuation, sheltering indoors • access control on land
Ministry of Social Affairs and Health	• iodine prophylaxis
Valvira	• safety of domestic water (protection, limiting use) • safety of indoor areas and the living environment (protection, decontamination, limiting use, waste management)
Finnish Food Safety Authority Evira [currently Finnish Food Authority]	• protection of livestock production and other primary production • safety of foodstuffs and suitability of feeds
Ministry of Agriculture and Forestry	• national introduction of the action limits (EU limits) of foodstuffs
Finnish Transport Agency [currently Finnish Transport Infrastructure Agency]	• closure of maritime space or a waterway; restrictions on road and rail traffic in accordance with decisions by the director of rescue operations
Finnish Transport Safety Agency Trafi [currently Traficom]	• aviation restrictions after 3 days
Supervisory authority responsible for environmental protection	• consideration of environmental protection aspects in decontamination measures and in waste management

Other operator	Area of responsibility
Ministry for Foreign Affairs	• informing the foreign representations in Finland when the radiological emergency reaches Finland • informing and providing instructions for Finnish representations for the purpose of protecting Finnish nationals when the radiological emergency extends to outside Finland
Finnish Defence Forces	• participation in the rescue operations by providing the rescue authorities with fleet, personnel and professional services • participation in the formation of the radiological situational picture
Finnish Customs	• radiation measurements at border crossing points • control of the import and export of foodstuffs and goods by means of radiation measurements
Police	• in accordance with the decision by the director of rescue operations, implementation of access restrictions, traffic control • public security and the safety of the public • in situations in breach of the law, management of operations
Finnish Border Guard	• warning and participating in the evacuation of the population living in archipelagos • in the affected area, warning maritime traffic, including boaters • participation in radiation measurements
Regional State Administrative Agencies	• coordination of the regional activities, situation monitoring, guidance and resource management
Centres for Economic Development, Transport and the Environment	• guiding functions in the relevant area of responsibility; safety of primary production and foodstuffs, water supply, guidance of the industrial sector, implementation of road traffic restrictions in accordance with the decisions by the director of rescue operations and guidelines by the Finnish Transport Agency
National Emergency Supply Agency	• communication of instructions to the private sector
Municipalities in the area affected	• responsibility for carrying out the measures and for safeguarding the continuity of all functions

ANNEX 5:
Exposure mitigating effect of sheltering indoors

Moving indoors and shutting down ventilation is a good way to protect against the exposure caused by a radioactive plume. This mitigates both the exposure from external radiation and the amounts of radioactive materials entering indoor air and, consequently, the exposure via inhalation and the contamination of indoor areas.

Exposure from external radiation

Construction materials significantly reduce the dose rate of external radiation. Figure 3-1 shows the protection provided by the rooms of a structurally typical apartment building and detached house against external radiation from radioactive material originating from outside these buildings.

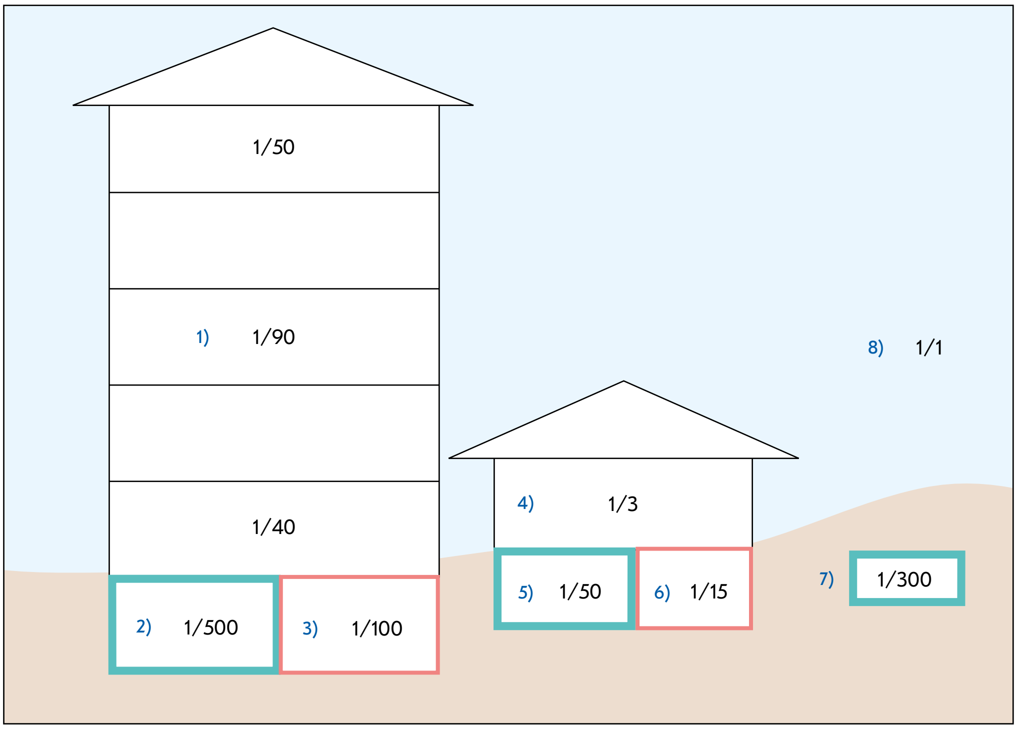


FIGURE 3-1. Protective factors of buildings in figures. Buildings protect against external radiation from radioactive material originating from outside buildings. If, for example, the dose rate outdoors is 100 μSv/h, in the lowermost floor of an apartment building it is 2.5 μSv/h.

1 reinforced concrete frame apartment building; the calculations assume that the middle parts of each floor, not rooms with windows in the exterior wall, are used for sheltering
2 air raid shelter of an apartment building
3 cellar facilities of an apartment building
4 typical detached house with a wooden structure
5 underground areas of a detached house, precast concrete intermediate floor
6 underground areas of a detached house, wooden intermediate floor
7 self-made shelter, such as an earth cellar
8 no protection outdoors provided by any structures

Inhalation exposure from radioactive materials entering indoor air

Sheltering in an airtight building materially reduces exposure via inhalation, especially if particulate radioactive matter occurs in outdoor air only for a short period of time.

As a consequence of an accident, the amount of radioactive material in outdoor air may rise suddenly. Noble gases and gaseous iodine compounds penetrate into indoor air after a slight delay. Some radioactive materials attached to particles will also enter indoor areas. The leaky sections include the joints of doors and windows as well as pipe penetrations in the floor and roof.

In an airtight house where it is possible to shut down ventilation, it can be assumed that all air changes once every 10 hours. In a non-airtight house or in a house where it is not possible to shut down ventilation, it can be assumed that all indoor changes once every 2 hours. Table 3-l contains some examples of protection efficiency.

The examples given in table 3-l assume that the concentration of airborne radioactive materials remains constant during the passage of the radioactive plume and that ventilation of indoor areas is initiated one hour after the plume has moved out of the locality. Additionally, the calculations assume that the indoor area is furnished[8], meaning that more particles attach to various surfaces than would be the case with unfurnished areas. The calculations do not account for any particles filtering at the leaky sections of buildings. Although the internal dose from noble gases is, in practice, insignificant, they are also included in the table as an example of gaseous radioactive material, such as gaseous iodine (methyl iodide), entering indoor air.

8 Furnished indoor area where the time constant describing particle attachment to various surfaces is 0.3 h-1

TABLE 3-L. Protection efficiency depending on house ventilation.

Duration of sheltering indoors[9]	Protection efficiency in a house where the indoor air changes once every 10 hours		Protection efficiency in a house where the indoor air changes once every 2 hours	
	particulate radioactive material	noble gases	particulate radioactive material	noble gases
2 hours	90%	85%	55%	45%
5 hours	85%	75%	45%	25%
10 hours	80%	60%	40%	10%
24 hours	75%	35%	40%	5%

Full advantage can be taken of sheltering indoors when indoor areas are ventilated immediately after the passage of the release plume, when outdoor air has become decontaminated. If no ventilation is carried out at all or if it is delayed by several hours, some of the advantage derived from sheltering indoors is lost. For example, if the passage of a radioactive plume takes 4 hours and ventilation of an airtight house is started one hour after the plume has left the locality, protection efficiency is 85% where particulate radioactive material is concerned. Where ventilation is started in two hours, protection efficiency goes down to 80%, and ventilation that starts in five hours reduces protection efficiency to 75%.

Where noble gases and gaseous radioactive material are concerned, ventilation assumes heightened importance. Employing the above example, ventilation that starts in one hour in an airtight house provides protection efficiency of 75%. If ventilation starts in two hours, protection efficiency is 65%. If ventilation starts in five hours, protection efficiency is 50%.

Some particulate radioactive material remains on various surfaces in indoor areas even after ventilation. That is why it is necessary to clean the indoor areas carefully when the sheltering indoors ends and the areas are ventilated. If the areas are not cleaned, radioactive material can be re-suspended into the air later and end up in the air inhaled.

9 The duration of sheltering indoors equals the time it takes for the plume to pass + 1 hour, when ventilation of the indoor areas is started

ANNEX 6: Personal protective equipment of emergency workers, emergency helpers and other workers

In the early phase of a radiological emergency when the outdoor air contains radioactive material, protective equipment is to be used whenever moving outdoors in all areas where sheltering indoors or access control is necessary or where it is necessary to limit the time spent outdoors. In the intermediate phase when inhaled air has decontaminated and there are radioactive materials on all surfaces, the need for protection is dependent on the type of fallout and on whether the work in question is such that radioactive material can be re-suspended from contaminated surfaces into inhaled air (for example, dusty work).

Skin, hair and inhalation are protected against radioactive particles by means of protective clothing, protective gloves and shoes and a respirator (P3).

Respirators reduce the internal exposure from inhalation caused by radioactive material. In a nuclear power plant accident, gaseous radioactive iodine, which a respirator does not filter, can be released into the environment. Airborne iodine travels via inhalation into the lungs, from where the majority of this iodine finally accumulates into the thyroid. Taking an iodine pill before starting work prevents the accumulation of radioactive iodine in the thyroid.

Protective clothing, gloves and shoes are all intended to protect your own clothing, skin and hair against particulate radioactive material. When selecting these, two alternatives are available: disposable protective equipment, or protective equipment that can be decontaminated. Disposable protective equipment includes Tyvek overalls, shoe protectors and protective gloves. Overalls made of the Tyvek material feature overtaped double seams, and they are resistant to penetration by radioactive particles. The material is very breathable. Protective equipment that can be decontaminated (washed) include rubber booths and rubber gloves.

When purchasing protective equipment, the protection that is otherwise linked to the work in question should be considered. For example, protective equipment in health care and emergency care can consist of protective equipment that protects against contagious diseases. Additionally, iodine pills are necessary. It is vital to keep all protective clothing and other equipment ready and available for rapid and sustained developments.

At the scene of accident, the rescue authorities wear the appropriate protective equipment. Whenever the scene of accident contains or may contain any radioactive material, a respirator must be part of the protective equipment. Outside the scene of accident, the rescue department takes steps to prepare for using the same protective equipment as is used by the other parties involved.

It is essential to follow the instructions given whenever using, putting on or taking off any personal protective equipment.

ANNEX 7:
Independent mitigation of exposure in a contaminated area in the intermediate phase

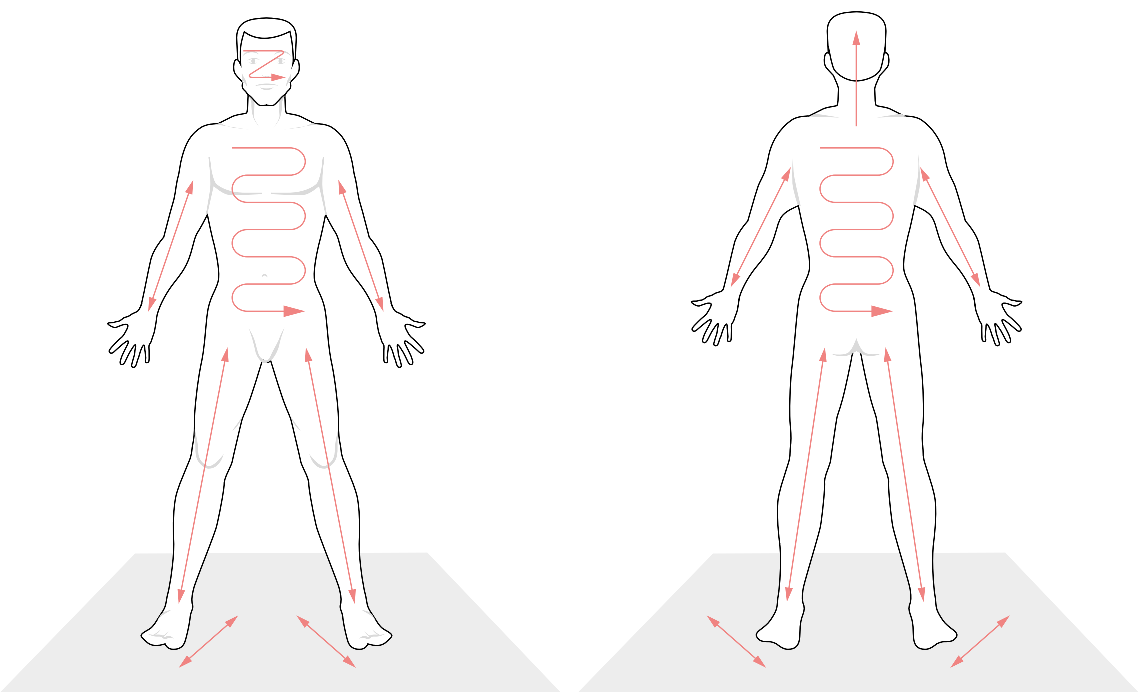
In a contaminated area, people can independently mitigate radiation exposure. Exposure can be mitigated at home and in the workplace. In addition to the home, special attention must be paid to day care centres, schools and other facilities where children and young people spend time. The relevant authorities will communicate the areas where these measures are necessary. Below are some examples of the measures for mitigating exposure.

- In indoor areas, simple ventilation and cleaning such as vacuuming, wiping and washing reduce the radiation dose significantly. If no cleaning is carried out, radioactive material can be transmitted from contaminated surfaces into the human body. During cleaning activities, protective clothing should be used where necessary, and in dusty work a respirator should be used. Cleaning is particularly important whenever shelter indoors was sought only after radioactive material had already been introduced into the area, in which case the indoor areas were contaminated. It is necessary to repeat the cleaning measures, since humans as well as pets taken outside carry new radioactive material into indoor areas. Ventilation and cleaning must be initiated as quickly as possible after contamination.
- Washing removes radioactive materials from the skin and hair and reduces their entry into the human body. Frequent and careful washing of hands is particularly important.
- Leaving outdoor clothing and shoes by the door when entering a building, as well as washing and changing of clothes, reduces the degree of recontamination of indoor areas. Also pets should be cleaned before entering an indoor area, as they carry radioactive material indoors on their legs and fur.
- Air filters should be replaced or cleaned as quickly as possible after the passage of the radioactive plume in buildings and in any vehicles and work machines where ventilation was on during the passage of the plume or that use natural ventilation. This prevents radioactive materials attached to filters from coming loose and entering indoor areas.
- Decontamination of yards and the outer surfaces of buildings reduces the dose from the living environment. During decontamination activities, protective clothing should be used, and in dusty work a respirator should be used.
- The dose from foodstuffs is reduced by restricting the processing or use of self-grown foodstuffs, and such products as mushrooms, wild berries, fish and game.
- It is appropriate to decontaminate all vehicles, tools and goods in personal outdoor use, for example, by washing them with water. It may be necessary to repeat these decontamination measures if they are used in a contaminated area.
- Restricting the recreational use of natural areas, such as walking in forests in leisure time, during the first months decreases the contamination of clothing, hair and skin, as well as reducing exposure to external radiation.

ANNEX 8: Measurements taken on people

Radioactive materials in the human body

- The radiation level at the measurement point is measured before initiating any measurement activities.
- Measurements are performed using a meter that indicates the dose rate, as follows:
  - Protect the meter by means such as a plastic bag in order to prevent the meter from becoming contaminated.
  - Use the most sensitive meter settings, if it is possible to select them.
  - Keep the meter as close to the person measured as possible, but take care that the meter does not touch any clothing or skin. Move the meter slowly at a distance of less than five centimetres around the body as shown in the images below.
  - Where a measurement detects a dose rate that exceeds the dose rate prevailing at the measurement point, the outermost layer of clothing should be removed and the measurement repeated. This allows to determine whether the contamination is in the clothing or on the skin.
  - If the second measurement does not exceed 0.5 μSv/h, the person is provided with instructions for self-washing and how to clean their clothes and clean or dispose of other accessories. Where the prevailing dose rate is exceeded by more than 0.5 μSv/h, guide the persons to an organised decontamination point.



Thyroid measurement

- In order to measure the radioactive iodine in the thyroid, keep the meter for a period of 30 sec–1 min a few centimetres away from the thyroid.
- If this measurement records a reading that is at least 0.5 μSv/h more than the prevailing radiation level, guide the person to have more detailed measurements taken.

ANNEX 9:
Examples of decontamination measures concerning the built-up environment[10]

Subject	Decontamination measure and its possible efficiency, %	Notes
Outer surfaces of buildings	Demolition (100%)	Not urgent; usually possible in a small scale; lots of solid waste of various types
	Demolition and replacement of roof (100%)	Usually possible in a small scale; most effective soon after dry deposition; produces solid construction waste
	Pressure water spraying: roof and walls (25%)	Most effective when performed within approximately one week after deposition before rain; lots of water waste; waste may spread via splashes
	Brushing of roofs with water (50–75%)	No time constraints; produces water sludge (collection; routing to a designated location)
	Washing with a pressure washer: roof and walls, cold or hot water (35–80%)	Most effective when performed soon after deposition before rain; washing with hot water suitable for roofs; produces lots of sludgy water (collection; routing to a designated location); contamination may spread via splashes **Note** Not suitable for all surfaces; risk of moisture damage to structures must be considered
	Removal of snow from roof (100%)	Produces snow waste
	Painting with paint that catches radioactive materials (nearly 100%)	Catching efficiency nearly 100%, but account must be taken of radioactive materials when removing the coat of paint
	Others: sand blasting, treatment of walls with ammonium nitrate, mechanical action (wooden walls), peelable coatings (40–90%)	Usually possible in a small scale; both solid and liquid sludge waste

10 Generic handbook for assisting in the management of contaminated inhabited areas in Europe following a radiological emergency, version 2, March 2010 (EURANOS(CAT1)-TN(09)-03)

Subject	Decontamination measure and its possible efficiency, %	Notes
Indoor areas of buildings	Vacuuming (90%, depends on particle size)	Most effective immediately after contamination (must be repeated if more waste enters from outdoors); suitable for large-scale application; easy (independence); produces solid vacuum bag waste, dust
	Washing (35–50%)	Most effective when performed immediately; suitable for solid surfaces in large-scale applications (independence); produces water waste (collection; routing to a designated location)
	Cleaning of air-conditioning equipment / piping; replacement of filters (80–100%)	Most effective immediately after contamination; produces the following waste: solid filters, dust and water
	Others: shampoo wash, steam wash, brush scrubbing, removal of paint/wallpapers, removal of furniture, chemical cleaning methods (10–90%)	Usually possible in a small scale; best suited for industrial facilities; both solid and liquid sludge waste

Subject	Decontamination measure and its possible efficiency, %	Notes
Roads and paved areas	Pressure water spraying (50–75%)	Most effective within one week of dry deposition before rain; produces sludgy water waste
	Vacuuming with water (50–65%)	Most effective within one week of dry deposition before rain; produces sludge water waste
	Pressure washer wash (65–85%)	Most effective when performed soon after deposition before rain; can also be performed later; produces water waste
	Removal/replacement of surface material (80–90%)	Most effective when performed soon after deposition; can also be performed later; difficult to perform in a large scale; produces asphalt and similar waste.
	Removal of snow (90%)	Most effective when performed swiftly; produces snow waste (collection and routing to a designated location)

Subject	Decontamination measure and its possible efficiency, %	Notes
Land areas and green spaces, yards, vegetable patches	Lawn mowing (50–90%)	Effective within one week after dry deposition before rain; easy to perform (independence); produces biological waste (collection)
	Removal of plants and small bushes (50–90%)	Effective within one week after dry deposition before rain; produces lots of biological waste (collection)
	Removal of lawn (including roots) (65–90%)	Most effective fairly soon after deposition; however recommended only after the first rain when washings from other surfaces (buildings, roads) have washed into this layer; lots of biological waste (collection)
	Removal of topmost soil and lawn (90–95%)	Remains effective years after deposition; recommended only after the first rain when washings from other surfaces (buildings, roads) have washed into this layer; requires a great deal of work; produces lots of mixed soil and biological waste (collection)
	Removal of snow (90–100%)	Most effective soon after deposition; easy to perform (independence); produces snow waste (collection)
Trees and bushes	Collection of leaves (with non-coniferous trees, 90–100%)	Suitable for non-coniferous trees; should be performed immediately after leaves fall (before rains or combustion); easy to perform (independence); biological waste (collection)
	Pruning/removal (90–100%)	Most effective when performed within one month of deposition (and before leaves fall); biological waste (collection)
	Removal of snow from trees (50–90%)	Most effective after deposition; can be combined with other snow removal activity; produces snow waste (collection)

The factors affecting how decontamination measures are selected and prioritised include the following:

- radioactive materials and their amounts
- weather conditions prevailing during and after contamination, for example rain
- extent of contaminated areas
- character of surfaces to be cleaned
- effectiveness of the desired cleaning, time and resources needed for cleaning
- time of season
- the public in the area to be decontaminated, which affects the urgency and possibility of the public to participate in cleaning of immediate surroundings.

ANNEX 10
Examples of measures concerning the living environment

If radioactive material cannot be removed from the living environment, it could be appropriate to have it fixed where it is or cover the contaminated surfaces. This will limit the potential for re-suspension of radioactive material into inhaled air, contamination of people and spreading of radioactive material into a non-contaminated area. Fixing material will not decrease the external dose rate due to external gamma radiation or strong beta radiation. However, the external dose rate can also be reduced by covering contaminated surfaces with a thick enough layer of clean material.

Fixing radioactive material can be either temporary or permanent. Additionally, any surface treated by means of an appropriate fixing method, together with the fixer agent, can be removed later. Fixing radioactive material to surfaces may also be appropriate whenever the half-life of a nuclide that emits alpha or beta radiation is relatively short or when the contamination consists of only certain alpha or beta nuclides (such as Pu-239) and other decontamination measures are difficult to carry out.

Possible fixing options include the following[11]:

- paint on external building surface: protection against inhalation of[12] re-suspended material, protection against external gamma and reduction of external beta radiation;
    - effectiveness: a 45% reduction in the dose rate of strontium-90; could also be considered for indoor surfaces of buildings
- sand on roads and paved areas: protection against inhalation of re-suspended material, protection against external gamma and reduction of external beta radiation;
    - effectiveness: a thin layer (2mm) reduces the dose rate of strontium-90 by 90%
- bitumen on roads and paved areas: protection against inhalation of re-suspended material, protection against external gamma and reduction of external beta radiation;
    - effectiveness: a thin layer (1mm) reduces the dose rate of strontium-90 by 70%. Wear to be considered in the thickness of the surface used
- treatment of dusty roads and paved areas with anti-dust agents reduces inhalation of re-suspended material;
    - covering roads and paved areas temporarily with water: reduces inhalation of re-suspended material; a very short-term interim option.
    - contaminated surfaces can be covered by means such as:
        - asphalting the surfaces
        - covering them with clean soil
        - ploughing yards and lawns.

11 Generic handbook for assisting in the management of contaminated inhabited areas in Europe following a radiological emergency, version 2, March 2010 (EURANOS(CAT1)-TN(09)-03

12 Re-suspension means that radioactive material that has fallen on surfaces is re-suspended into the air.

ANNEX II: Examples of measures concerning primary production, water supply and further processing in the intermediate phase

Measures concerning primary production

With regard to the production of foodstuffs, a number of measures are available to reduce the activity concentration of the food produced. The suitability of the selected measures is affected by the extent, strength and radionuclides of the radiological situation, the timing of contamination, the foodstuffs concerned, and the production conditions in the area. Food products that are not suitable for human consumption can in some cases be used as feed for animals kept for purposes other than food production.

Foodstuffs of animal origin

Examples of measures to reduce the contamination of foodstuffs:

- **Clean feeds**. Use clean feeds to feed animals. It may be necessary to purchase them from outside the contaminated area or to alter the composition of the feeds used to feed animals.
- **Cleanliness of drinking water**. Contaminated rainwater or surface water must not be used as drinking water for animals.
- **Additives in feeding**. Add substances into animal feeds that prevent radioactive material from becoming absorbed from feed into animals. AFCF (Ammonium-ferric-cyano-ferrate(II), also known as Prussian blue) reduces the absorption of radioactive caesium. Clay minerals can also be used to reduce the absorption of radioactive caesium from feeds into the metabolism of animals. Calcium is added to reduce the intake of radioactive strontium from food. Additionally, reindeer can be given rocks containing minerals for licking in order to reduce the amount of caesium in reindeer meat.
- **Measures relating to animal slaughtering**. The times when animals are slaughtered can be changed in such a way that slaughtering is carried out before contaminated feed has appreciably contaminated the meat derived from an animal. Another option is to plan the time of slaughtering in such a manner that, before slaughtering, clean feed is used for feeding purposes for a sufficiently long period of time, thereby ensuring the usability of meat.

In some cases, it is useful to measure radioactive material directly in live production animals in order to be able to ensure the usability of the meat products in advance. Measurements can also be employed for the purpose of planning the feeding of animals.

Additionally, milk production can be reduced, for example, by changing the feeding patterns of animals if this is possible without endangering animal health. Where it is not possible over a long time span to produce clean foodstuffs in a contaminated area, it may be necessary to end milk and meat production in part or completely.

Crop production

Examples of measures to reduce the contamination of crops:

- **Cleanliness of irrigation water**. Contaminated rainwater or surface water must never be used to irrigate any kitchen gardens.
- **Removal of crops**. Crop removal also aims to remove radioactive material from fields and kitchen gardens in order to safeguard clean soil. This measure is effective immediately after the deposition arrives and, in particular, before the first rain. Discretion can be exercised to leave crops that are less contaminated on the field.
- **Soil surface peeling (thin layer)**. Possible in a moderate scale, for example in horticulture.
- **Ploughing**. Ploughing makes radioactive material move deeper from the surface of the soil and mix with a large layer of soil. This is how radioactive material moves away from the area that the roots of plants reach, at least in part, depending of the depth of the layer ploughed. The concentration of radioactive material in the soil is diluted as it mixes with a larger layer of soil. Tillage makes some radioactive materials, such as caesium, attach to the clay material present in the soil in such a way that they are not available to plants. Part of normal cultivation activity, this measure is possible over large tracts of land and it can be intensified by repeating it.
- **Fertilisation and land improvement**. Improve the availability of normal plant nutrients, thereby reducing the intake of radioactive materials with similar chemical behaviour. This measure is effective only if the original nutrient situation is poor.
- **Selecting crops for cultivation**. Select crops for cultivation that are produced in such a manner that no radioactive material, or only a limited amount of radioactive material, ends up from the raw material into the final product. Such products include alcohol and sugar. Crops not used as foodstuffs, such as energy production crops, can also be selected for cultivation.
- **Removal of snow**. This measure is at its most efficient when carried out quickly after the deposition arrives. Suitable for kitchen gardens, for example; not possible to implement in large areas of arable production.

Where it is not possible to obtain enough clean foodstuffs or feeds from a production area, the type of land use can be converted by transitioning from the production of foodstuffs to, for example, forest production or the area is used for some other purpose.

Measures concerning water supply

In a radiological emergency, efforts are made to obtain clean raw water. In summertime, surface water becomes contaminated in the event of a deposition. At winter, if a body of water is frozen, surface water remains uncontaminated for as long as melt water starts to flow into the body of water. Groundwater remains uncontaminated.

Where domestic water is not sufficiently clean, clean water must be distributed to people by specific means such as with tanker trucks.

With regard to water supply, possible methods include the following:

- **New water abstraction facility**. Whenever possible, switch to using groundwater abstraction facilities or a water abstraction facility situated in a decontaminated area.
- **New location for water abstraction in bodies of surface water**. Water can be abstracted from a new body of water that is above the contaminated section. Clean water is abstracted from a deeper section until radioactive material has become mixed with and diluted in the entire mass of water.
- **Enhancing water purification treatment at waterworks**.

Measures relating to further processing
In further processing, only limited opportunities exist to reduce the amounts of radioactive material contained in final products. Some raw materials with a radioactive material concentration not exceeding the limits laid down can be processed into foodstuffs in such a manner that no radioactive material, or only a limited amount of radioactive material, ends up during production from the raw material into the final foodstuff:

- Milk can be processed into foodstuffs that keep for a long time, such as cheese, in which case short-lived radioactive material, including iodine, disappear completely during the period for which these foodstuffs are stored.
- In some production processes such as the manufacture of sugar, only a limited amount of radioactive material ends up in final products without any special measures.

Additionally, in food production and processing it is possible to remove some of the radioactive material:

- Surface contamination can be removed with careful washing or peeling.
- Radioactive material contained in mushrooms can be removed with water by boiling or soaking.
- Meat can be cured by soaking it in brine, which removes materials such as caesium from the meat into the brine.

ANNEX 12: Average consumption of foodstuffs in Finland

	Children one to two years old, kg/year	Adults, 25–64 years old, kg/year
Wheat	7	22
Rye	1.8	15
Oat, barley	7.5	3
Potato	26	27
Leaf vegetables	20[1]	7
Root vegetables		12
Fruiting vegetables		26
Fruits	20	53
Berries	5	8
Milk[2]	100	105
Butter		5.8[3]
Cheese		14
Beef	5.5	8.8
Pork	4.75	10
Mutton, game, intestines		0.5
Poultry meat		12
Eggs	1	7
Fish	1.8	11

There is very high variation between people in terms of the amounts consumed. Consumption patterns develop over time.

1 Includes all vegetables
2 Includes milk and milk products
3 Includes all milk fats

Sources:

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ANNEX 13: EU concentration limits for foodstuffs following the Chernobyl and Fukushima accidents

Concentration limits following the Chernobyl accident

Following the Chernobyl accident, the concentration limits set out below are in force in respect of foodstuffs imported from non-EU countries: total concentration of caesium-137 and caesium-134 in milk products and baby food, 370 Bq/kg; in other foodstuffs, 600 Bq/kg[13].

For natural product held for sale, including game, mushrooms, wild berries and predatory fish species in lakes, a Commission recommendation is in force[14] setting out that the total caesium-137 and caesium-134 concentration of products must not be more than 600 Bq/kg in intra-EU trade.

The concentration limits resulting from the Chernobyl accident will be discontinued, if the concentration limits laid down in Council Regulation (Euratom) 2016/52 are introduced on account of a new radiological emergency.

Concentration limits following the Fukushima accident

Following the Fukushima accident, all foodstuffs imported into the EU are subject to the same concentration limits as are laid down in Japanese legislation in respect of products sold inside Japan: the total caesium-137 and caesium-134 concentration in milk products and baby food, 50 Bq/kg; in other foodstuffs, 100 Bq/kg; and in mineral water and tea, 10 Bq/kg[15].

13 Council Regulation (EC) No 733/2008, Commission Regulation (EC) No 1635/2006, Commission Regulation (EC) No 1609/2000

14 2003/274/Euratom

15 Commission Implementing Regulation (EU) 2016/6

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